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INDIAN AGRICULTURAL
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THE JOURNAL
of the
TEXTILE INSTITUTE

VOL. XXXI—1940

PROCEEDINGS AND INDEX

THE JOURNAL OF THE
TEXTILE INSTITUTE

Vol. XXXI JANUARY 1940 No. 1

PROCEEDINGS

Lancashire Section

TEXTILE APPLIANCES AND THEIR VALUE IN CLOTH PRODUCTION*

Mr. Hall took the view that most of his audience were more particularly concerned with the production of yarns or cloth than with the actual application or production of auxiliaries and their possibilities. Given a piece of cloth what could be made of it? How could it be improved with the aid of these auxiliaries which are now to be purchased in such great numbers?

Formerly and up to shortly after the last war, auxiliaries were products of a comparatively simple nature. They were used mainly for facilitating the dyeing and finishing of textile materials. For example in order to get good penetration and level dyeing it was advised to add soap to the dye bath. To obtain a soft handle, a good quality soap or oil was used for impregnating the material in the finishing operations. An auxiliary was considered to be a simple assistant in dyeing and finishing. In these circumstances the characteristics of a fabric were determined mainly by the amounts and nature of the fibres present and not by any auxiliaries used in its processing.

Since the Great War much progress has been made in the large scale production of innumerable organic compounds which were formerly chemical rarities but which have now been found to be capable of useful application to textiles. Many of them possess the more valuable property of being able to modify textile fibres so markedly that they make less important the actual nature and amount of the fibres present in the textile material.

Many of the new auxiliaries are derived from substances scarcely known to chemists 30 or 40 years ago, but to-day they can be obtained at moderate prices and in quantities limited only by the demand. Many new chemicals (potential auxiliaries) are awaiting investigation so that to-day there are many opportunities for textile processors.

The characteristics of fabrics with which most people are concerned are appearance, handle (softness and draping qualities), stiffness (fabrics for collars and cuffs), strength and durability. The shrinkage of the material in washing and wear is also important. Other valuable characteristics are lustre, especially for rayon, and resistance to creasing. But in general it is impossible to produce fabrics that have all desirable characteristics without some which are not free from objection.

Some of the applications of auxiliaries to textile materials from the view oint of these various desirable characteristics were then discussed.

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bstract of a Lecture by A. J. Hall, Esq., B.Sc., A.I.C. to the Lancashire Section of the Textile Institute at Nelson on Thursday, December 7th, 1939, J. S. Whitham, Esq., in the Chair.

Softness. Formerly it was usual to impregnate the textile material with an oil or wax in order to give it softness. Olive oil emulsions and sulphonated fatty acids (for example, Turkey red oil) were largely used for this purpose. All such methods of softening were unsatisfactory since the softening agent could be removed by washing. More recent methods use auxiliaries which are compounds having a fat or wax residue joined to another residue which is capable of reacting with the textile fibre substance so as to link the first residue to it permanently. Pyridine plays an important part in the preparation of such complex softening auxiliaries, and it is sometimes arranged that in the textile treatment the pyridine is removed since its permanent presence in the fibre is not desirable or beneficial.

Stiffness. A high degree of stiffness in a yarn or fabric is generally attainable only by cementing the individual fibres together by use of an adhesive. It is most difficult to make textile materials stiff by coating the fibres and leaving them separate. When the fibres are not free, the yarn and the fabric become brittle and this is a marked disadvantage. Individual fibres may be stiffened by an internal filling with a resin, but this may also lead to brittleness. Parchmentation of cellulosic materials with concentrated acids may be used for stiffening.

Water Repellency. Formerly deposition of an aluminium soap in the textile material was the method most generally employed for waterproofing. More recent methods use one-bath processes in which there is applied to the fabric an emulsion containing wax and an aluminium salt.

Waterproofing may also be effected by coating the material with rubber. But the most recent methods use auxiliaries which when applied to the textile material, dried at a low temperature, and then baked at an elevated temperature for a few minutes, enter into chemical combination with the fibres so as to give water repellency which is fast to washing and dry cleaning. Velan PF (I.C.I., Ltd.) is an example of this type of auxiliary.

Water-repellency is important quite apart from making a yarn or fabric resistant to wetting. It is important to make textile fibres, especially artificial fibres, water-repellent so that their properties are not adversely affected by wetting. For example, viscose rayon temporarily loses 50 per cent. to 60 per cent. in tensile strength when wetted. Apparently this is due to a widening of the spaces between the micellae due to the entry of water. It would thus be extremely useful if an auxiliary were available by which this effect of water could be avoided without actually preventing the absorption of water by the fibre.

Crease-resistance. The inferiority of cotton and rayon to wool and silk in respect to their resistance to creasing is well known and it is an important factor in the production of dress materials. But by use of special urea-formaldehyde synthetic resins formed within cotton and cellulose rayon fibres it is possible to make these fibres as resistant to creasing as wool and silk. Such beneficial effects may be produced by the Tootal crease-resistant process.

It appears possible to produce crease resistance by other methods using rubber, but on the whole the Tootal process seems to be most practical and is widely used.

Unshrinkability. In the case of textile materials not containing wool, resistance to shrinkage during washing may be produced by a mechanical closing up of the warp and particularly the weft threads in finishing (Sanforised and Rigmel finishes). This is virtually a removal from the fabrics of the strains introduced in processing. Unshrinkability can also be secured by the deposition in the fibres of a synthetic resin as in the crease-resistance process. But in the case of wool materials it is necessary to eliminate from the wool its felting power. Various processes are available for making wool non-felting and they are based on the use of active chlorine in one form or other. Recently sulphuryl chloride has been introduced as a new auxiliary for this purpose. It is used in the Drisol process which involves treating the wool with a 20 per cent. solution of this auxiliary in white spirit, followed by neutralisation and washing. The object of such wool treatment is to produce non-felting without simultaneously reducing the durability of the wool by removal of the epithelial scales or otherwise.

Double texture and stiffened fabrics. Stiffened fabrics such as are used for the collars and cuffs of men's shirts were formerly made by sewing together two layers of fabric. Nowadays this method has been abandoned in favour of cementing the two fabrics together by a thermoplastic auxiliary which may be a cellulose derivative (e.g. cellulose acetate) or a highly polymerised resin. The "Trubenising" process utilises cellulose acetate. These new thermoplastic auxiliaries are in many respects superior to the rubber adhesives formerly used and they are likely to become very important.

Throughout the lecture Mr. Hall referred with considerable detail to various practical procedures whereby the auxiliaries described could be used for improving and modifying the properties of different types of fabric.

DYESTUFFS CONTROL*

The requirements of the Royal Navy, Army and Air Forces, together with the Auxiliary Forces for Home Defence, have resulted in very large and abnormal demands for dyed wool and cotton textiles.

The British dyestuff manufacturers are making every effort to increase their output to meet these abnormal demands and have indeed made extraordinary progress, but they are faced with two main difficulties:—

1. Many of their fundamental raw products are required also for war purposes.
2. Delivery of new plant for extensions cannot be obtained at a normal rate owing to armament requirements.

There is a definite world shortage of certain foreign dyestuffs and whilst continuous efforts are being made to increase our imports from allied and neutral countries, it must be borne in mind that valuable foreign exchange has to be utilised for their purchase. It is essential, therefore, that after service demands have been satisfied, the best use should be made of the dyes left available ; in present circumstances this means that home trade requirements for dyestuffs must yield preference to the requirements of export trade.

The Controller of Dyestuffs wishes to inform colour users that licences to acquire dyestuffs not made in this country, will be granted only on the condition that such dyestuffs are reserved, as far as practicable, for the services and export trade.

It will be necessary for users to preserve evidence of the actual use made of these dyestuffs to be available if proof is at any time required.

The dyestuffs position in Great Britain is immeasurably superior to-day to that in 1914, but the possibility of a shortage of dyestuffs for home trade requirements must be envisaged. It is, consequently, necessary for the home trade to plan its coloured merchandise requirements so that the consumption of the available dyestuffs may be spread over as large a weight of merchandise as is practicable.

The Dyestuffs Control Committee suggest that economy in dyestuffs may be obtained, for example, by reduction in the depth of heavy shades such as navy, nigger, bottle green and wine. The designers should also be asked to introduce paler shades in coloured woven and print designs, thus reducing the weight of dyestuffs required in the finished design. Other economies may also suggest themselves to users.

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[*] Reproduced at the request of the Dyestuffs Control Committee.

Obituary—Mr. Arthur Pollitt, F.T.I.

Arthur Pollitt, whose death took place on Wednesday, January 3rd, had one aim and object in life, namely, to serve in the fullest the Textile Industry. Although in his later years it might be said that his work was particular rather than general, it can be affirmed that for a very considerable period of his life he gave willingly and wholeheartedly of his knowledge for the benefit of his fellow workers in that industry.

In a quiet, unassuming but characteristically thorough manner he assisted many movements for the dissemination of textile technical information. He was practically a founder member of the British Association of Textile Works Managers, and he was very largely responsible for the production of the journal of that society, a journal which at the outset published information of an invaluable character. Arthur Pollitt recognised the fact that the journal should be a useful advertising medium, and he it was who first suggested the introduction of advertising pages, and secured those pages, so that the journal became practically self supporting.

He was ever ready in discussion and his contributions demonstrated a wealth of knowledge and an acute perception of facts which were characteristic of the man. He had educated himself as an engineer, and when the mill over which he had charge changed over to electric driving he acted as his own consultant, indicating very clearly his somewhat unusual attainments.

Although in later years, as stated, he devoted himself more to his own business connections than to the British Association of Textile Works Managers, in which he had held high office, he always retained a very warm interest in the activities of that body and attended whenever he could find the opportunity. He was undoubtedly a fine example of the Lancashire industrialists who, starting at a very low level, trained themselves for high positions which they subsequently filled so admirably. It was not an easy task in the early days to secure knowledge and to achieve such positions. Arthur Pollitt was one man who found the way. To those who knew him his passing will be a great loss. His unassuming character and his great readiness to assist in every possible direction where the progress of the textile industry was at stake endeared him to everyone with whom he worked.

FRANK NASMITH.

Professor Dr. Paul Krais

It is with deep regret that we record the death of one of our best known foreign members. Dr. Paul Krais had a distinguished career as a student of chemistry and after graduating in 1891 served for seven years with the Farbenfabriken, formerly F. Bayer & Co., in Elberfeld. He then came to England and within two years was chief chemist to the Bradford Dyers' Association Ltd. Many of his colleagues of those days have happy recollections of his leadership and geniality.

In 1918 he became Chairman of the newly established Research Institute for the Textile Industry, in Dresden, and in 1923 he took over the complete direction. Though an independent organisation, the Institute was closely associated with the Technical High School, Dresden, much of the research work being conducted by students working for academic honours. In recognition of this position, Dr. Krais was appointed a Professor and from 1927 was actually engaged not only at the Institute but also as Honorary Professor of Textile Chemistry at the Technical High School. He retired in 1934.

His great interest was the improvement of the fastness to light of cotton dyes. On this problem he contributed a number of scientific papers and was always ready with practical advice from a ripe experience, but he will perhaps be best remembered as the Chairman of the German Fastness Commission. In the early days of scientific textile research he developed several ingenious instruments for testing the properties of single fibres and more recently he described a method for analysing a mixture of staple fibre and cotton.

Professor Krais became a member of the Textile Institute in 1924 and always took a keen interest in the *Journal* and Conferences. He contributed to the *Journal* an original paper entitled "The Tensile Testing of Single Wool Fibres" (1928, Vol. 19, T32-36) which describes his well-known "Deforden" apparatus for testing the breaking load and extension of single fibres. This instrument, with certain modern refinements, is now widely used for such measurements in Germany.

Professor Krais had suffered from a painful illness during the past two years and died in Dresden on October 8th, 1939, aged 73 years.

Institute Diplomas

Elections to Fellowship and Associateship have been completed as follows since the appearance of the previous list (December issue of this *Journal*).

ASSOCIATESHIPS

JAMES ASHTON
VICTOR DAITZ

FELLOWSHIPS

A. W. BAYES
A. H. HOLDEN
J. C. H. HURD
EDWARD SLATTERY

Midlands Section

Visit postponed

It is regretted that the visit which was to have been paid to the silk mill of Messrs. Windley & Co. Ltd., on Wednesday, 21st February, has had to be postponed. Circumstances have changed since the arrangements were made, but if it is possible to re-arrange the visit at a later date members will be informed.

"THE JOURNAL OF THE TEXTILE INSTITUTE"

Enquiries for Early Issues

The Textile Institute frequently receive enquiries for back numbers of *The Textile Institute Journal*, some of which are out of print. Should any member consider the disposal of his set, particularly if it contains issues of the years 1910 to 1923 inclusive, the Institute would greatly appreciate the opportunity to acquire the same.

The Annual Indexes for 1922 and 1926 to 1931 inclusive are out of print, and the Institute will be glad to receive copies from members who no longer wish to retain them.

THE JOURNAL OF THE
TEXTILE INSTITUTE

Vol. XXXI FEBRUARY 1940 No. 2

PROCEEDINGS

NOTES AND ANNOUNCEMENTS

Annual General Meeting, 24th April, 1940

The Annual General Meeting will take place at the Institute's premises on Wednesday, 24th April, 1940. Members are urged to note this date and to make every effort to attend.

Council Election, 1940

Ten of the thirty members of Council retire annually and the names of the present members together with the years in which they are due to retire are as follows:—

1940	1941	1942
Barnes, H. C.	Chamberlain, J.	Bromiley, H.
Chadwick, F.	Dalton, J. E.	Crompton, W. B.
Davis, Wm.	Goodall, J. R. S.	Day, J.
Greenwood, H.	Greg, H. G.	Gee, N. C.
Howarth, Wm.	Haigh, G.	Harwood, F. C.
Nisbet, H.	Lord, R.	Kendall, F.
Porter, F. C.	Morton, W. E.	Kershaw, S.
Stevenson, A. W.	Richardson, H.	Read, J.
Wildt, E.	Speakman, J. B.	Slater, F. P.
Wilkinson, Wm.	Thompson, G. H.	Withers, J. C.

Election takes place at the Annual Meeting, and nomination forms will be supplied to all members of the Institute so that candidates for the ten vacancies occurring in 1940 may be nominated.

In this issue of the *Journal* will be found a table indicating possible and actual attendances at meetings of Council and Committees. The list of attendances does not include the names of the President, Past-Presidents, or Vice Presidents, as these gentlemen are not eligible for nomination to Council vacancies.

Regulations for the Election of Associates and Fellows

The Regulations which have recently been revised are now available in the new form. Copies may be obtained on application to the Acting Secretary.

Examinations

The Preliminary Examination and the Examination in General Textile Technology will be held as usual in May of this year. Applicants for the Associateship who have been referred to either of these examinations and who wish to become candidates, this year, are asked to complete forms of entry as early as possible.

Institute Diplomas

THESES FOR THE F.T.I. DIPLOMA

According to the " Regulations concerning Applications for the Fellowship," Associates applying for the Fellowship are required to produce evidence that they have added materially to the advancement of textile technology. For this purpose it may be necessary for some candidates to produce special papers or " theses " for consideration by the Diplomas Committee, and the following notes are written for their guidance.

Generally speaking the Committee will expect to find in such a thesis a record of an original experimental or other investigation conducted by the candidate himself or under his leadership. The candidate should select a subject about which existing knowledge is imperfect and on which the means at his disposal are adequate to provide further knowledge. It should be noted that these means need not include the equipment of a scientific research laboratory, even for experimental work ; much can be done with the resources available in schools, mills and factories.

The thesis should open with a statement of the problem, showing what the candidate intends to investigate, why he considers his project one that will add " materially to the advancement of textile technology ", and how he proposes to obtain the required experimental or other evidence. This opening statement would usefully include a review of published information on the subject, especially if it showed that previous knowledge was meagre or inexact. The thesis should then give a detailed account of the actual work undertaken by the candidate, including a description of any new apparatus or devices constructed for the purpose, particulars of the procedure followed, and a record of all the relevant measurements or other observations. This part of the thesis should be carefully set out in an orderly fashion and with all the evidence necessary to enable a competent critic to judge whether the results obtained rest on a sure foundation and whether the author has made a true contribution to knowledge. Adequate illustrations should be provided ; in some investigations these might include samples of yarn or fabric. The thesis should conclude with a discussion of the collected data and a clear statement of the conclusions drawn from them.

Alternatively, it may sometimes be thought preferable to follow the opening statement with only a brief outline of the procedure so that the conclusions can be presented to the reader early in the thesis. In such cases the body of experimental detail or collected data, or both, would be relegated to the final section.

In short, the essential features of a thesis for the Diploma are:—

1. A statement of the reasons for the investigation.
2. A clear account of the candidate's own work in the investigation.
3. A discussion of the conclusions drawn.

The thesis should of course be written in good English and literary form.

It should be understood that a thesis drafted as suggested above might not, at the same time, be suitable for publication in the *Journal of the Textile Institute*. For example, some sections that would properly be expounded at length in a thesis might require to be cut down to bare outlines before acceptance for publication.

Election to Associateship has been completed as follows since the appearance of the previous list (January issue of this *Journal*).

ASSOCIATESHIP

A. R. A. HAMED.

Institute Membership

At the February meeting of the Council, the following applicants were elected to membership of the Institute:—

Ordinary

C. G. Booth, Valley Mill, Drighlington, Bradford (Woollen Manufacturer).

H. Castle, 124, Springfield Terrace, Bradley Mills, Huddersfield (Assistant Manager, John Brooke & Sons Ltd., Huddersfield).

G. L. Godman, 317, Barnerhouse Road, Nelson (Research Chemist, Lustrafil Ltd., Valley Mills, Nelson).

E. Jackson, 35, Daffodil Road, Farnworth, Lancs. (Assistant Loom Overlooker).

J. Klinger, 14, Cumberland Street, Manchester, 3 (Expert for Silk and Rayon Weaving Mills, Tester and Designer).

J. Montgomery, Glenwood, Kingsway, Dunmurry, Co. Antrim (Linen Merchant).

J. Morris, 7, Amelia Street, Saltaire, Shipley (Drawing Overlooker).

A. C. Mudaliar, 94, Brick Kiln Road, Perambur Barracks, Madras (Assistant Spinning Master, Buckingham & Carnatic Co. Ltd., Madras).

M. K. Mukhopadhyay, 46/B, Ritchie Road, Ballygunge, Calcutta (Senior Tester, Research Laboratories, Indian Central Jute Committee).

J. Pemberton, 12, Union Road, Tonge Moor, Bolton (Assistant Warehouseman).

H. Preston, Westleigh, Holme, nr. Burnley [Director, Cotton Waste Co. (James Baron & Sons Ltd.)].

F. C. Toy, Shirley Institute, Didsbury, Manchester (Deputy Director, Shirley Institute).

Miss Bertha Warburton, Tootal Broadhurst Lee Co. Ltd., 56, Oxford Street, Manchester, 1 (Assistant in Textile Testing and Research Dept.)

J. F. Wareham, c/o George Henderson & Co. Ltd., 101/1, Clive Street, Calcutta, India (Chemist, The Kassipur Co. Ltd., and Barnagore Jute Factory Co. Ltd.)

J. C. Williams, 75, Warde Street, Manchester, 15 (Textile Viewer, War Office).

Junior

G. I. Barraclough, Bents Cottage, Hallas Bridge, Cullingworth, nr. Bradford (Worsted Drawing and Spinning Overlooker).

A. Burrows, c/o J. R. Burrows, Carlinghow Mills, Batley [Salesman (Textile) and Student].

J. Cooper, 39, Clifton Street, Kearsley, Farnworth [Cotton Operative (Side Piecer)].

N. Cowan, 1, Broad Oak Road, Worsley, nr. Manchester (Textile Apprentice and Student).

G. Feher, Devonshire Hall, Cumberland Road, Headingley, Leeds, 6 (Textile Student).

J. Hartshorn, 118, Harpers Lane, Bolton (Rayon Technologist).

C. B. Haworth, 216, Chorley Old Road, Bolton (Trainee in Cotton Textiles and Student).

T. Lowe, 33, Lyndhurst Street, Bolton (Assistant Overlooker, Ring Room).

D. F. Paling, Cossall, Notts. (Textile Student, Nottingham University College).

G. M. Smith, c/o Mrs. Woolley, 88, Sherwood Street, Nottingham (Textile Student at Nottingham University College).

W. S. Sondhelm, 3, High Street, C.-on-M., Manchester, 13 (Research Student).

ATTENDANCE REGISTER

	Council	Finance and General Purposes	Diplomas	Publications	Textile and Designs	Scholarships	U.T.M.C.	Development	Examinations Board	Editorial	Emergency
	8	9	9	9	5	1	5	1	5	4	6
Ashworth, J.	..	..	..	..	..	..	2	..	..	..	..
Baguley, N. G.	..	..	..	..	..	..	2	..	..	..	..
Barnes, H. C.	7	..	..	..	2	..	..	1	..	..	6
Baron, J. W.	..	..	..	..	..	1	..	..	..	..	..
Barr, J.	..	..	..	..	..	..	3	..	..	..	..
Barritt, J.	..	..	..	8*	..	..	..	..	..	..	..
Bayes, A. W.	..	..	..	8	..	..	5	..	..	3	..
Beswick, J. L.	..	..	..	..	1	..	..	..	..	..	..
Boothman, W. T.	..	..	..	..	..	0	..	..	..	..	..
Bownas, C.	..	..	..	..	1	..	..	..	..	..	..
Brindle, J. L.	..	..	..	..	0	..	..	..	..	..	..
Bromiley, H.	3	..	3	..	..	..	..	..	..	..	..
Brookes, H.	..	..	..	..	1	..	..	..	..	..	..
Chadwick, F.	3	..	..	..	..	1	..	..	..	..	..
Chamberlain, J.	2	..	1	..	..	..	..	..	..	..	..
Clapperton, G.	..	..	..	..	..	1	..	..	..	..	..
Crompton, W. B.	7	..	..	..	4	..	..	..	..	..	..
Cunliffe, P. W.	..	..	..	6	..	..	1	..	..	..	..
Dalton, J. E.	7	..	7	..	..	1	..	0	..	3	..
Davis, W.	2	..	0	0	..	..	..	..	1	..	..
†Day, J.	3	..	..	..	..	..	..	..	..	..	..
Dilks, H. L.	..	..	..	..	4	..	..	..	..	..	..
Dumville, J.	..	..	..	5	..	..	..	..	..	..	..
English, W.	..	..	..	..	..	..	..	..	..	3	..
Foulds, R. P.	..	..	..	2	..	..	..	..	..	..	..
French, W.	..	..	..	..	..	..	..	..	..	1	..
Gee, N. C.	5	..	..	..	..	..	..	..	..	..	..
Gibson, W. H.	..	..	..	0*	..	..	1	..	..	..	..
Goodall, F. L.	..	..	..	2	..	..	0	..	..	..	..
†Goodall, J. R. S.	2	..	1	..	..	..	..	1	1	..	..
Greenwood, H.	6	..	..	..	..	..	..	..	..	..	..
Greg, H. G.	7	..	..	..	2	1	..	1	..	..	..
Haigh, G.	3	3	..	..	1	..	..	..	..	..	..
Harwood, F. C.	2	..	3	1*	..	..	2	..	..	..	..
Hollas, J.	..	..	..	..	0	..	..	..	..	..	..
Howarth, W.	2	5	..	..	..	0	..	1	..	..	..
Kendall, F.	5	..	5	..	..	..	..	0	..	..	..
Kershaw, S.	4	..	..	..	..	..	..	..	5	1	..
King, W. E.	..	..	8	..	..	..	..	..	..	..	..
Lantz, L. A.	..	..	..	..	..	..	4	..	..	..	..
Lomax, J.	..	..	..	..	..	..	2	..	..	..	..
Lord, R.	4	..	..	..	2	1	..	..	..	..	..

* Representing a Research Association.

† Serving in His Majesty's Forces.

Attendance Register—continued

	Council	Finance and General Purposes	Diplomas	Publications	Textiles and Designs	Scholarships	U.T.M.C.	Development	Examinations Board	Editorial	Emergency
	8	9	9	9	5	1	5	1	5	4	6
Matthew, J. A.	..	..	0	..	..	..	..	..	..	..	..
Morton, W. E.	4	..	7	3	..	..	..	0	5	..	6
McCall, R. W.	..	..	..	..	..	..	..	..	..	0	..
Nisbet, H.	7	..	..	5	3	..	..	..	..	..	..
Parsons, H. L.	..	..	..	..	..	..	..	..	..	0	..
Pennington, J. W.	..	..	..	3	..	..	..	..	..	..	..
Pickard, Sir R.	..	..	0	7*	..	..	3	..	..	..	..
Porter, F. C.	8	8	7	..	2	0	..	..	..	..	..
Pritchard, W.	..	..	..	..	..	..	1	..	..	..	..
Read, J.	3	3	..	4	..	..	..	..	..	2	..
Richardson, H.	1	..	..	..	..	..	..	..	..	2	..
Roberts, E. M.	..	..	..	..	2	..	..	..	..	..	..
Robinson, T. H.	..	..	..	..	..	..	..	..	..	0	..
Salt, H.	..	..	1	..	..	..	..	..	..	..	..
Scholefield, F.	..	..	2	..	..	..	..	..	5	..	..
Slater, F. P.	0	..	..	0	..	..	0	..	..	..	..
Speakman, J. B.	0	..	..	1	..	..	..	..	..	..	..
Stevenson, A. W.	1	..	0	0	..	..	..	..	..	..	..
Swan, E.	..	..	..	..	..	..	..	..	..	4	..
Tansley, L. B.	..	..	..	..	..	..	3	..	..	..	..
Thompson, G. H.	6	2	..	8	..	1	..	..	..	..	5
Watson, W.	..	..	0	..	..	..	..	..	..	..	..
Whitelegg, C. J.	..	..	..	..	..	..	..	..	..	2	..
Whittaker, C. M.	..	..	..	2	..	..	..	..	..	..	..
Wildt, E.	0	..	0	..	1	..	..	..	..	..	..
Wilkinson, W	4	..	0	..	..	..	..	..	2	..	..
Wilsdon, B H.	..	..	0	..	..	..	2	..	..	..	..
Winson, C. G.	..	..	..	..	..	..	..	1	..	..	..
Withers, J. C.	8	..	3	8*	..	..	..	..	..	..	5
Wood, F. C.	..	..	..	1	..	..	..	..	..	..	..

* Representing a Research Association.

Yorkshire Section

JUTE AND ITS UTILISATION *

By S. G. Barker.

It is not the intention of this paper to deal with the production or the extraction of jute from the plant, except in a very brief manner. This has been very ably described by Finlow in his paper in the Proceedings of the Textile Institute as reported in the *Journal of the Textile Institute*, September, 1939. Briefly, it may be said that there are two species of jute, namely, *Corchorus capsularis* and *Corchorus olitorius*. Incidentally the fibre from *olitorius* is redder than from the *capsularis*, which in some cases is almost white.

Originally, it is stated, jute was found not only in India, but also in Egypt, Arabia and Palestine, and it is significant that the development of these countries at the present time is signalled by the revival of attempts at jute cultivation.

To give some idea of the importance of jute as an industrial raw material, it may be recorded that India produces 98 per cent. of the jute of the world and that it is the world's second largest textile industry. As regards acreage, the total area under jute in the four provinces of Bengal, including Cooch Behar and Tripura States, Bihar, Orissa and Assam, is estimated at 3,118,700 acres during 1939, showing a fall of 45,800 acres from that in the preceding year. The area in Bengal under jute shows an increase of 28,100 acres, while Bihar, Orissa and Assam respectively account for a drop of 50,000, 2,400 and 21,500 acres over the estimates for 1938. The only significant alternative is Formosa, which has 66,000 acres. This indicates that 99 per cent. of the acreage of the world under jute is in India. It is important to note that little of the jute, either raw or manufactured, is retained in India itself, and practically the whole of it is exported. India's export of raw jute to the United Kingdom is the only important trade movement of raw jute within the Empire.

Finlow states that the average of many hundreds of crop cutting experiments leads to the conclusion that for the whole of the jute growing tracts, an average crop, in a normal season, is probably over three bales (1 bale equals 400 lbs.), equivalent to 15 maunds, per acre, but less than 3·5 bales (17·5 maunds) per acre. Thus, if the total area of jute is estimated at 3,000,000 acres, and the average yield is found to be 3·3 bales per acre, the total crop would be 10 million bales. If the average yield is only 3 bales per acre, the total yield would be 9 million bales. India's jute crop in 1939 yielded 9,646,300 bales, being an increase of 2,802,750 bales on last year's outturn.

Add to this the fact that the production and over 50 per cent. of the subsequent textile processing is carried out within some 300 miles round Calcutta, as also the fact that the raw material can be brought direct by river to the Calcutta mills, one has some idea of the concentration of the industry and its vast nature. In good years, 25 per cent. of the total exports of India are accounted for by the jute industry, and turning to world figures, over 70 per cent. of the raw materials of the world are packed and transported in jute containers.

The cultivation of jute is essentially an industry for small holders, since there are no large plantations, but each small holding of jute is from 1 to 3 acres. This necessarily means a very large number of people engaged in production, and of course, the fact that so many people are individually and independently interested in both growth and extraction, renders it difficult to prevent variability in the qualities of the fibre as marketed.

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* A lecture to the Yorkshire Section of the Textile Institute at Bradford on Thursday, 11th January, 1940, Mr. J. R. Emms in the Chair.

The industry from the agricultural point of view interests some 9 million people and in the mills round Calcutta, over 300,000 operatives are engaged. There seems to be a rather erroneous idea in this country as to the status of the Indian jute industry, but it should be clearly understood that it is in point of efficiency, the best organised in the world, and in point of equipment and technical skill, produces adequate materials under excellent conditions regarding machinery, factory equipment and mill premises.

The cultivation of the fibre in India is limited to what might be called the delta of the Ganges, Brahmaputra and Surma Rivers, which is largely a series of alluvial mud flats. As Finlow points out, in certain places on the coast of the Bay of Bengal, the land face is being advanced by one mile per annum, due to the deposits of alluvial mud and silt. It is this annual flooding with subsequent deposition of soil, silt and alluvial materials which, when the floods subside, yields fertile land for jute cultivation. Natural circumstances, both climatic and geographical, combine in this way to give the most suitable and almost exclusive land for jute cultivation in the world, and furthermore to provide an almost monopolistic area for its production.

The statistics quoted give you some idea of the scope of the jute manufacturing industry, and just one or two points may be noted in passing, in regard to each section. (These were illustrated with slides.)

There must be no illusion in the mind of anybody that the Indian manufacturing industry is anything but right up to date. It must be clearly understood that we are studying a mass-production industry dealing mainly with the production of cheap packing materials, and as such, since the price factor is of paramount importance, the manufacturing processes employed are, in general, an exemplification of the basic principle of textile processing.

Dyeing and finishing are restricted and subordinated in their scope, compared with those of the wool industries, but demands for hygienic containers and packing materials to meet specific requirements of the customer, have received such consideration that greater attention is being paid to what might be called " chemical processes and finishes." The inauguration of the Research Department was the first step in this direction, and it is beginning to yield results which as far as the business man can see, may have a practical future.

Let us devote attention to the fibre itself, its origin and production, and endeavour to show how some of its limitations may be modified. In order that we may understand something of the raw material with which we are dealing, I would like to quote one or two of the findings of Professor J. H. Priestley, of Leeds University, and his staff, who have spent very considerable time on studying the method of formation of jute. We cannot do better than review briefly how the fibre is formed in the plant.

If a strand of commercial jute is examined, it will be seen to be composed of a network of fibres joined tangentially but not radially. These fibres may be described as being in layers round a central core. Naturally, the outside layer is more open than the inside, having a larger area to cover and being the product of an earlier stage of the plant growth. These cylindrical networks result from the method of formation, viz. as secondary growths formed from the cambium. The commercial fibres, if viewed in a transverse section of the plant, form radiating groups with soft tissues in between. The tissue of which the fibres are made is formed by growth from within. Cambium cells are of two kinds in jute, elongated cells running lengthwise, which give rise to new fibres, and short cells which also divide up and give rise to new rays.

It is because the fibril network is formed always on the outside of the interrupted cylinder of elongated cambium cells, that it possesses this network structure, and may be considered as a secondary growth. The outermost fibres, therefore, are the oldest part of the network which are continually being stretched further and further apart.

Let us compare the outermost and innermost layers of such network. It is seen that the outer fibres are thicker and the inner fibres are finer. It is of course understood that the number of ultimate fibrils in the fibre groups will vary along the stem, and Kundu has shown that the number really corresponds to the rate of growth of the plant. The following table illustrates the results of actual measurement, whilst the one following gives dimensional details of the size of such fibres.

Internode of main stem.	Number of Fibres.
1 (lowest)	314
5	1,361
10	2,016
15	1,974
19	1,750

	Outer Group.	Inner Group.
Average length	3 565 mm.	1·468 mm.
Average width	19μ	15μ
Longest fibre	6·380 mm.	3·281 mm.
Shortest fibre	0·646 mm.	0·442 mm.
Widest fibre	32μ	24μ
Narrowest fibre	10μ	10μ

We should also note points where the leaf stems have entered into the plant and it is obvious that on the outer fibre layers these points are much more prominent and marked than on the inner layers. It would seem that the point of entry signifies the place where the soft tissues separate with greatest difficulty from the fibre when retted. The outer network gives conspicuous examples of this. Furthermore, the fibres at these points are suddenly changed in direction, exhibiting sharp curves and possibly their thickness is reduced, even to the question of petering out. They may prove to be points of weakness. We thus establish straight away the fact that, differing from flax and other fibres of a similar character, jute is a secondary fibre.

Let us now turn to the fibre itself, from the chemical point of view. Under the auspices of the Indian Jute Mills Association, A. G. Norman determined the chemical nature of the fibre and he found that quite apart from the fact that there is considerable lignin therein, the cellulose itself contained a goodly proportion of xylan. Xylan is very closely allied to cellulose, as its formula shows. It is probably laid down in the plant growth simultaneously with the cellulose itself. The length of the xylan chain is probably about half that of the cellulose and hence we would expect that a high proportion of xylan would reflect on the manufacturing value of the fibre, in that a smaller length of chain would give a deficiency in strength. This apparently is so, but the fibre bundle in jute is illustrated by Sommer as not in any way deficient in strength. The trouble is that we fail entirely to transfer this strength into the yarn. Sommer's table shows that whilst, for example, wool has a breaking length of 8·5, jute is 32-35, but when we come to elasticity, however, we find jute very low and it is probably on this account that the extent of its utilisation is limited.

It is, however, not the intention of this paper to emphasise further the various characteristics of the fibre, except in so far as they are relevant to the main issue, that is its utilisation for sandbags and the like. It would seem that a very distinct bias against jute has been created by the fact that the sandbags which have been utilised for revetments throughout the country, have all rotted within three months, and people have raised the question as to whether there was not a more durable textile fibre for the purpose.

Dr. Thaysen, of the Chemical Research Laboratory, has investigated this question, and has very kindly placed at my disposal, facts and figures which he has determined on this issue. In the first place, rot being a living organism should be inhibited by the presence of a poison, and in the second place, since a high moisture content is essential for rot to take place then it might be possible to protect the fibre by some water-repellent medium.

There are, therefore, two ways in which the fibre should be possible of protection. (1) Shielding. (2) By the incorporation of some antiseptic or toxic material. Dr. Thaysen protected material with glass, aluminium, rubber, and vaseline, and in his criticism his results present the following data.

Shielding of Fabrics in Relation to Micro-Biological Attack.

In soil exposures it is shown that the rate of deterioration is inversely proportional to the weight of the fabric, the heavier the fabric the longer would it retain the essential part of its tensile strength. Again, closely woven material is more resistant than loosely woven or light material of the same fibre. This may be due to the protection afforded by the surface hairs against the penetration of moisture, but subsequent experiment shows that shielding is the main issue. Shielding of a fabric by rubber, aluminium or glass makes the protected material retain its tensile strength longer on exposure in soil or immersed in seawater than unshielded material of identical description. The following results are typical:—

Nature of Shielding.	Number of days' exposure until complete breakdown when torn by the hand.
Nil	28
Glass	119
Aluminium	105
Rubber	105
Vaseline	32

Protection due to shielding is not due to elimination of moisture, but is due to absence of contact (direct) between the active source of infection and the shielded fabric. Intimate contact between cellulose-digesting micro-organisms and the material they are to attack is essential. If such direct contact is prevented by the introduction of an inert substance between the contaminated cellulose debris of the soil and the fabric to be attacked, infection can occur only through free cellulose decomposing organisms present in soil waters which may seep into the fabric with the moisture. The infection of shielded fabrics thus progresses more slowly and particularly one should note that a large amount of growth has to establish itself on the fibres before a noticeable loss of tensile strength can be recorded. If one places a piece of fabric in soil unprotected, then after two weeks, intimate contact is noted by the adherence of the soil to the fabric. An effectively protected fabric will not have adhering soil matter after weeks of exposure. Thus intimate contact of soil and fabric is essential. Variation of this often leads to entirely erroneous results in comparative tests. It is interesting to note that rubber latex and other types of pure rubber compositions, waxes, linseed oil and aluminium soaps tested in no case afforded anything more than temporary protection of the fabric. Their useful application is thus limited. The same may be said of bitumen.

Relative Resistance of Different Fibres to Decay

In jute fibres, which are surrounded by parenchymatous tissue, sufficiently coherent and continuous to retard the action of such drastic swelling agents as strong alkalis, a different type of shielding was possible and in order to test whether or not this was the case as also to get some idea of the comparative resistance to decay of fabrics made of different textile fibres, an experiment was performed where one hemp fabric, two flax fabrics and one cotton fabric were exposed under identical conditions in active garden soil. The fabrics were not, however, of the same weight or structure, but by assuming the deterioration would be inversely proportional to the weight of the fabric, and expressing this weight as the strength of the dew-retted flax sample as basic unit interesting figures were obtained. These are reproduced below:—

Type of Fabric AND weight per 100 square cm.		Number of days for fabric to lose strength to be torn by hand.	Calculated number of days for the standard deterioration to be reached on comparative basis of dew retted flax weight.
FABRIC.	WEIGHT.		
Dew retted Flax ...	4·42 gms.	20	20
Water retted Flax ...	4·42 gms.	20	20
Hemp	4·42 gms.	21	20
Jute	7·47 gms.	35	21
Cotton	1·78 gms.	14	35

It will be seen that flax, hemp and jute rotted at almost identical rates, whilst cotton deteriorated more slowly. The latter conclusion is made from a much lighter fabric than the others and therefore its significance is somewhat impaired. The results do not indicate that the presence of lignin in the jute, nor its parenchymatous sheath on the fibres delays the rotting of the fibre materially beyond that of pure cellulose.

The above results lead us to the conclusion that no matter which textile fibre had been used, either expensive or otherwise, the development of rot would have been the same and, in point of fact, jute has actually been superior to most others, whilst at the same time it was cheap. For the temporary protection which it has afforded over the initial period of the War, it is therefore obvious that nothing better could have been done, but now that a more permanent state of affairs seems to be established, the question arises as to efficiency and efficacy of various antiseptics which may be used.

The first point at issue is the relative value of these media, and it may be said that creosote for timber as set out in British Standard Specification No. 144/1936, placed upon the fibre to the extent of 25 per cent. of its weight gives a very efficient proof, whilst if an organic copper salt is also added the efficiency is greatly enhanced. On the other hand Thaysen has conducted some comparative tests with various media which are interesting. Before discussing his table one should point out that climatic exposure such as is encountered in the case of sandbags is something quite unique for jute or any other fibre since the agencies to which it is submitted in exposure are comparatively unimportant during manufacture, transit and normal use, or storage as bags or sacks.

Damage by fungus attack during manufacture, storage and transit is restricted largely to attack by lower fungi, whilst climatic conditions bring into play micro-organisms comprising bacteria, fungi and actinomycetes. The lower fungal attack can be countered largely by suitable fungicide incorporation, but since good fungicides are often poor bactericides, this expedient often fails for climatic exposure. The latter incorporates the action of leaching out, volatilisation and sunlight, which all reduce the resistance to micro-organisms of the fabric and also eliminate or render inactive, many inhibitory substances. Climatic exposures are much more exacting than ordinary wear and tear and are more complex, therefore they form a distinct and separate problem. Thus, for climatic exposures, the ideal inhibitor is one which is only slightly soluble, is non-volatile, and unaffected by actinic rays. It should possess both fungicidal and bactericidal properties. The need for only slightly soluble media implies that the toxic substances will function only when in the closest possible proximity to the place of deposition on the fabric. It should be evenly distributed both on and in the fibre, so that every individual fibre and part of the fibre composing the fabric should be affected. Thus we get the trouble arising from uneven application of shielding materials as also of impregnation with antiseptics. The value of protective substances can best be expressed by employing a method of burying in the earth which is active and although it may be drastic, yet it is only representative of possible actual conditions in use. A control can be buried alongside each time and thus the ratio of the time for complete loss of strength can be determined under similar conditions between both treated and untreated material. The variation of tensile strength due to variations in the original fabrics such as jute, renders the exact valuation of the strength difficult. The time for complete disintegration is the final and certain criterion in every case. The following table evaluates the rotproofing qualities of the media tested by taking the ratio for the time for complete breakdown of similar treated material under similar exposure conditions. The first three substances are shielding methods, whilst the others are toxic incorporation.

Method of Treatment	Soil Exposure		Sea Exposure		Ratio of Destruction Periods
	Untreated	Treated	Untreated	Treated	
Shielding.					
Latex	—	—	17	35	1 : 2·1
Light yellow aromatic oil	—	—	10	14	1 : 1·4
Aluminium Soap	49	49	—	—	1 : 1·0
Toxin Incorporation					
Cutch	—	—	10	13	1 : 1·3
Chromium/Cutch	66	158	—	—	1 : 2·4
Sodium Silicofluoride	26	26	—	—	1 : 1·0
Xanthoxin	66	60	—	—	1 0·9
Proflavine	25	60	—	—	1 . 2·4
Acriflavine	25	60	—	—	1 : 2·4
2% diphenylamine fluorosilicate	26	40	—	—	1 : 1·5
Iron Chromium (Linen)	66	127	—	—	1 : 1·9
Iron Chromium (Cotton)	127	235	—	—	1 : 1·9
Copper Naphthenate	66	143	—	—	1 : 2·2
Copper Oleate	—	—	25	71	1 . 2·8
Acetylation	45	2,645	—	—	1 : 58·8

It is noteworthy that in no case in these tests, except that of acetylation, which is of course the actual chemical change in the fibre surface itself, did the antiseptic action prolong the life of the fibre more than three times. These results, however, must only be interpreted in the light of micro-organic attack, and must not be judged from the textile point of view ; nevertheless they are quite informative. It must be emphasised, however, that for ordinary conditions, jute can be preserved so as to give very much longer performance than is normal, and in this regard, it is superior to most other textile fibres.

When one considers its cheapness, plus its remarkable textile and rot-resistant properties, we are justified in stating that no other fibre would do better for sandbag and other work, and few would do as well.

Recently it has been stated that wool sheets made from jute have rotted. In this regard I would suggest investigation of the treatment of such sheets by cuprous oxide, which is now a proprietary product for rot-prevention purposes. There are many methods of rotproofing for this particular requirement, and there is no need for complaints of this character to occur. In any case, it is unlikely that such rot would be transmitted to the wool, since the prime factors in micro-organic attack on any fibre are dampness and high humidity conditions. In these circumstances, taking into consideration utility, price and every other factor, jute still remains what it was, the best and most economic material for its present uses.

Correspondence

Technical Societies and Their Functions

To the Editor.

Sir,

We may surely conclude that the general situation of world affairs is causing reflection in the minds of thinking people particularly the scientific and technical members of the community. As typical examples of the intelligentsia in the best sense, and being further enormously concerned with social development, maintenance and progress, they cannot be ignorant of present conditions, nor of their special effects on themselves as individuals. Collectively, scientists as a class are not so intimately organised as to secure effective expression and representation of their distinctive standpoint and specific views. The medical profession and certain bodies such as civil engineers, possess united and powerful organisations safeguarding their interests ; but the large and widely distributed class of scientific and technical workers is not so represented. Consider, for example, those—numbering several thousands—engaged in the textile industries. They have the Textile Institute and the Society of Dyers and Colourists. Now both these organisations can fairly be described as " publishing houses " on the one hand and " lecture agencies " on the other ; in both respects on a purely voluntary and non-commercial basis. Their principal function, which is extremely valuable and essential, is the publication among their membership of original papers and summarised abstracts of recent developments or current practice. Some slight co-operative effort is provided by occasional conferences.

But the tremendous factors of the social results of the scientific or technical work of their members receive no attention, consideration or control from these bodies. All the enormous implications of this specialised social effort are in these societies ignored. Such papers or lectures as may occasionally invade the economic field hardly get beyond mere works costings. In fact, it may be broadly stated that the entire efforts of the scientific and technical staffs of the textile industries, apart from work production, are controlled by non-scientific and non-technical persons of the financial type. Leaving for the present the question whether this peculiar structure is best adapted for maximum production, it will scarcely be held that it favours future progress, and in particular, scientific and industrial research. To-day, the idea that England still leads the world industrially and developmentally in research must be abandoned ; in respect of general technical production we are no longer first and are relatively losing further ground. Does not this phenomenon concern the scientific and technical staffs of industry? Are not their personal interests vitally involved therein?

The immediate issue I wish to raise in this communication is that of enlarging the scope, work, and functions of our technical societies. They must no longer be restricted to the dissemination of details of the daily technical duties of their members. In a rationally organised community, scientific publication, particularly of new discovery, would be the job of national departments effectively subsidised. Science in which discoveries are made, and technics, in which science is applied to practice, must now be organised, developed and controlled for the salvation of mankind in the future. This is the task of the scientists and technicians themselves, and their working media must be their own special organisations.

Put briefly, I am suggesting the broadening of these bodies, their immediate extension into the field of textile economics, the collection and publication of economic data and the general preparation for new industrial development on the economic side. Is there any element in the industry which is alive to the situation? Is it realised that this is to-day the question of questions? Science and technical industry will not remain static, certainly not in particular foreign countries. Can we, in England, afford to continue as at present, resting on past achievement ; must we not rather, with scientific progress as our goal, bestir ourselves to new endeavour?

(Signed) J. SCHOFIELD, F.Inst.P.

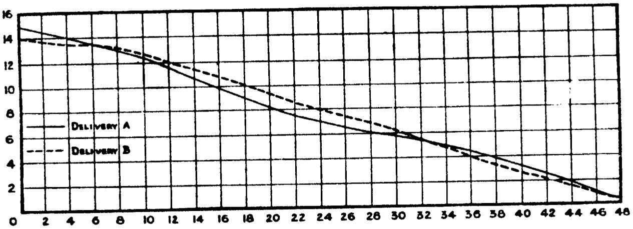
A Graphical Method of Recording Wool Top Fibre Diagrams

To the Editor

Sir,

The simple method described below affords a quick and ready means of recording graphically fibre diagrams of deliveries of wool tops.

The apparatus consisted of a velvet-covered board 14 in. long and 9 in. wide. Hinged on one of the long sides is a celluloid window in a wooden frame. The window is divided into squares by means of two sets of lines at right angles. The zero ordinate and zero abscissa are provided by fine wires stretched across the velvet.



Wool Top Fibre Diagrams.
Comparison between two deliveries of Tops.

In producing a record the usual precautions are observed to obtain a square edge on the sliver. A draw is then pulled and should this be satisfactory the figure on the velvet is made as follows. With the celluloid window lifted back, the tip of the pull is placed on the horizontal wire so that the edge of the draw is just on the vertical wire and the drawing proceeds in the usual way care being taken that a draw does not overlap the previous one, but just touches it.

On completion of the figure the window is placed in position on the board. The figure is then plotted on squared paper having 1/10 in. squares, the graph being roughly half-size. The other relevant particulars should be also noted on the paper, which should then be filed.

The above method will be found useful as a quick means of comparison especially for the spinner, as component tops in any blend may be compared by means of the graphs, or two or more curves may be plotted on the same paper, when comparisons would be simpler. It may also be used for the comparison of yarns, the fibres of which may be drawn from a length of untwisted yarn and a graph plotted as with a top.

In conclusion it cannot be too highly emphasized that the same person should be responsible for all the tests as no two persons would draw the fibres in the same way.

(Signed) G. E. SHEARD.

Leicester, *January*, 1940.

CORRECTIONS.

"TEXTILE AUXILIARIES AND THEIR VALUE IN CLOTH PRODUCTION"

Page P1.—The title should have been as here stated.
Page P3, line 2.—" 20 per cent." should read " 2·0 per cent."

Reviews

Modern Factory Lighting, including Special War-time Requirements. Issued jointly by the British Electrical Development Association and the E.L.M.A. Lighting Service Bureau, 2, Savoy Hill, London, W.C.2. (Pp. viii and 139. Price 8s. 6d.)

Most people who have had a scientific training insist on a cautious approach to a " popular " book on a scientific or technical subject. They realize what a difficult task the author has had and that he had frequently been forced to slur over difficulties because he is afraid of frightening his readers. The characteristics of the " popular " book are only too often acquired at the expense of accuracy and correct treatment. Fortunately there are notable exceptions and the volume under review can unhesitatingly be numbered among the select few.

The rush of modern life is one of the chief causes of the increasing specialisation which is everywhere so very evident to-day and which forces the specialist to depend so much on his brother specialists in other fields of activity. It would be unreasonable to ask the factory manager to have, in addition to his expert knowledge of his own trade, an equivalent experience in architecture, illumination, ventilation, etc. But it is well that he should have some accurate information so that he can co-operate with the specialist in the attainment of the best conditions for his particular branch of industry.

" Modern Factory Lighting " should be in the hands of all who are in control of industrial establishments. It presents simply and accurately much technical information of which the average man has only vague and often incorrect ideas. This applies particularly to Chapter III on the " Choice of Light Sources." No system is unduly praised by contrast with competitive methods for achieving the same result, viz. the proper illumination of the work in the most economical way. The advantages and disadvantages are discussed in the fairest possible way.

The inclusion of a chapter on " War-time Control of Factory Lighting " contains valuable suggestions for treatment under particular conditions and so makes the work absolutely up-to-date. Without any hesitation whatever, this book can be recommended to all who are interested in the important subject of factory illumination.

" Statute Law Relating to Employment." F. N. Ball, LL.D. (Thomas Bank Publishing Co. Ltd. Price 10s. net).

When the whole community craves for light in the general blackout, it is comforting to know that one section thereof has been supplied with light in regard to its own special and particular darkness. Those who seek information regarding the statutory position of an employer or an employee or both have for too long found themselves well-nigh lost in the sombre labyrinth which the many Acts of Parliament and the almost endless Regulations, spawned from these Acts, have created.

Having spent twenty years in legal practice and ten in industrial administration, I sighed with relief when I laid my hands on Mr. Ball's excellent book, fearful still that perhaps performance might lag behind promise, but glad in the end to be able to find performance so excellent. Here indeed is a torch in the blackout, a guide through the permutations and combinations of " whereases " and " wherefors," references to sections and subsections and appendices which

NOTICES—INSTITUTE MEETINGS

Tuesday	5th March	*Manchester*—2.0 p.m. Meeting of Publications Committee at the Institute.
Tuesday	5th March	*Manchester*—3.0 p.m. Meeting of Diplomas Committee at the Institute.
Wednesday	6th March	*Manchester*—2.30 p.m. Meeting of the Textiles and Designs Committee at the Institute.
Thursday	7th March	*Manchester*—2.0 p.m. Meeting of the Joint Committee *re* National Certificates in Textiles at the Institute.
Wednesday	13th March	*Manchester*—2.30 p.m. Meeting of the Finance and General Purposes Committee at the Institute.
Wednesday	20th March	*Manchester*—2.45 p.m. Meeting of the Council at the Institute.

LANCASHIRE SECTION

Wednesday	13th March	*Manchester*—6.30 p.m. Annual Meeting and Hot Pot Supper, at the Manchester Ltd. Café.
Wednesday	20th March	*Manchester*—6.30 p.m. Lecture, "Personality: A Man and His Work," by G. E. Wilson, at the Institute.

YORKSHIRE SECTION

Thursday	14th March	*Bradford*—7.0 p.m. Lecture, "Industrial Eyesight Problems," by J. Pike, Esq. (London), at the Midland Hotel.
Tuesday	19th March	*Bradford*—7.0 p.m. Annual Meeting and Yorkshire Section Committee Meeting at the Midland Hotel.

LONDON SECTION

Friday	15th March	6.15 p.m. Annual Meeting of the Section at the Northumberland Rooms, Northumberland Avenue, London, W.C.2, to be followed at 7.0 p.m. by a lecture entitled, "General Serviceability of Textiles," by N. G. Baguley, Esq.

OTHER ORGANISATIONS

Federation of Textile Societies and Kindred Organisations—

Saturday	9th March	*Rochdale*—2.30 p.m. Committee of Management at the "Flying Horse Hotel."

Blackburn Textile Society—

Friday	8th March	*Blackburn*—Lecture, "Loom Design," by E. Watson, Esq.
Friday	15th March	*Blackburn*—Lecture, "The Economic Running of a Power Plant," by H. Brown, Esq.
Saturday	16th March	*Bury*—Visit to Messrs. Robert Hall & Sons, Loom Makers, Bury.

Bolton and District Managers, Carders and Overlookers' Association—

Friday	8th March	*Rochdale*—Lantern Lecture, "Air Conditioning," by J. H. Hall, Esq., F.R.Met.S. (Messrs. Hall & Kay Ltd.), at the Old Clock Face Hotel, Lord Street, Rochdale.
Friday	15th March	*Bolton*—Talking Film, "Birth of a Ford," by arrangement with Ford Motor Co., at 8.0 p.m., at the Saddle Hotel, Bradshawgate, Bolton.

Bradford Textile Society—

Monday	18th March	*Bradford*—7.30 p.m. "Fancy Yarns," by C. Horner, Esq., at the Midland Hotel.

Dewsbury Textile Society—

Tuesday	5th March	*Dewsbury*—Inter-Society Discussion on the merits of Heavy Woollen and Morley Cloths (Joint meeting with the Morley Textile Society).
Tuesday	19th March	*Dewsbury*—Lecture, "Textile Testing," by J. Lomax, Esq., F.I.C. of Nottingham.

Preston and District Textile Society—

Monday	11th March	*Preston*—7.30 p.m. Lecture, "Finishing of Cotton and Rayon Fabrics," by F. L. Barrett, Esq., F.I.C., F.T.I., at the Technical Institute.

for so long have made even the most careful and determined investigators stumble by the way.

I commend this book for its lucidity, its accuracy and the invaluable time-saving which it is going to mean to civil servants (some of them sinners rescued from their own sinning), industrial administrators, trade unionists, members and officials of friendly societies, and law, accountancy, secretarial, local government, insurance broker, and other kindred types of students.

That the publishers have shown as much intelligence as the very intelligent author, is revealed by the fact that the former continue the good work of the latter by offering to keep the purchasers of the book up-to-date by providing a war-time emergency service of the Acts and Regulations relating to Employment.

As a lawyer, I was particularly pleased to read the excellent résumé of the Common Law in regard to reparation in respect of injuries which the author provides.

The book is divided into four parts, (1) that relating to the common law aspect of compensation to which I have referred, (2) that relating to compensation under the Workmen's Compensation Acts, (3) that relating to the insurance of the workers against the effects of ill health and unemployment, and (4) that relating to the health, safety and welfare of the workers.

In addition there are excellent appendices, dealing with such matters as employment of children, the Shop Acts, the Truck Acts, the Trade Board Acts, the Young Persons Employment Act, 1938, the Holidays with Pay Act, and Emergency (War) Legislation, affecting Employment.

If the student should find these appendices somewhat telegraphic in their statements, it is but fair to the author to remind him or her that the most that can be expected of that part of the book is a guide-post of a nature briefer than that provided by the book as a whole.

A. CRAWFORD.

Sulphated Oils and Allied Products—Their Chemistry and Analysis. By Donald Burton, M.B.E., D.Sc., F.I.C., and George F. Robertshaw, A.M.S.T., A.I.C. (London—A. Harvey, 1939. Pp. 163+Index. Price 12s. 6d.).

The origin of this book lies in the authors' attempt to suggest methods of analysing sulphated oils to the International Society of Leather Trades Chemists and its emphasis is predominantly on the analysis of products employed in the leather trade. Thirty-five pages are devoted to an historical survey, raw materials and the methods and chemistry of sulphation which have thus necessarily been dealt with only in survey, though here as elsewhere the book is extremely fully referenced. The remainder is analytical, nearly one hundred pages being devoted to sulphated oils, twenty pages to sulphated fatty alcohols and 10 pages to petroleum sulphonic acids. The analysis of other types from the now vast field of synthetic auxiliary products is not touched upon.

Especially in the section devoted to sulphated oils, the various analytical methods are fully and critically discussed. The reader is presented with a wealth of facts which though of obvious advantage to those already familiar with this type of work, may perhaps lead to some confusion in the minds of others. One could wish that the authors had given a little more guidance as to the course to be followed in, for example, the analysis of certain well-defined types, although the reviewer is well aware of the difficulties this would involve. The desirability of preliminary qualitative examination might also have been more emphasised. The section dealing with sulphated fatty alcohols is naturally more precise than that dealing with sulphated oils.

The testing of some of the " user " properties of sulphated oils and alcohols is very briefly touched upon, e.g. emulsifying and wetting power, though too briefly to be generally useful.

Despite points of criticism, however, this book remains a very useful correlation of analytical procedures. The matter is generally logically arranged ; it is adequately indexed, attractively printed on good paper and serviceably bound.

D. WARD.

Additions to the Library

Textile Fibres and Materials. By Richard Hünlich. Translated by A. J. Hall and Edited by H. P. Curtis. (First British Edition, 1939, 222 pages, 122 illustrations. Published by Thomas Skinner & Co., London. Price 8s. 6d. net.)

Nineteenth Annual Report of the Industrial Health Research Board. (To 30th June, 1939.) (London, His Majesty's Stationery Office. 6d. net.)

Analysis and Testing of Textiles. By. Shandar D. Vashist, B.Sc., M.Sc., A.I.C., A.T.I. (The Society of Textile Technologists, Cawnpore, India). [Presented by the Author.]

Pitman's "Textile Educator." Edited by L. J. Mills. (Parts 5-30 inclusive.) [Presented by F. C. Porter, Esq.]

The Manufacturer's Compendium. By J. S. Buckle (Whittaker & Co., London, 1864). [Presented by F. C. Porter, Esq.]

"Needle-Pointing" of Card Clothing in the Mill Treatise No. 23. Dronsfield Bros., Oldham.

Medical Research Council, Industrial Health Research Board. "A study of Accident Proneness among Motor Drivers." By E. Farmer and E. G. Chambers (London, H.M. Stationery Office. Price 9d. net).

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PROCEEDINGS

RAW WOOL AND ITS MANUFACTURE*

By Donald Wilson, A.T.I.

The use of wool, as a material from which articles of clothing could be manufactured, dates from the earliest days of the world's history. Long before man conceived the possibility of producing yarns from fibres of wool, which could be interlaced to form fabrics, the skins of sheep, with their fibrous covering, were used as a protection from the rigours of the climate. No other fibre has yet supplanted wool for retaining warmth and giving protection to the human body.

Many references from the Bible and the early classics, testify to the esteem in which wool was held by our forbears. One reference of interest may be taken from the Greek mythology, which records the adventures of Jason in search of the Golden Fleece. One is led to believe that this was the fleece of the ancient Moufflon, the father of all modern sheep. This type of sheep flourished in Mediterranean districts in the early days of civilisation, and grew a coat of wool, golden red in colour.

The history and commerce of our own country are very closely bound up with wool. For many centuries the long wools of England were supreme throughout the world, and England occupied the position of the world's most important producer of wool. Laws dealing particularly with wool and its manufacture were enacted, thus indicating the importance of wool to the commerce of this country. In the fourteenth century, three-quarters of the Customs revenue of this country came from the trading in wool, and articles manufactured from it. Symbolic of this importance is the "Woolsack," the official seat of the Lord Chancellor, in the House of Lords.

Since "imitation is the sincerest form of flattery," wool may consider itself highly complimented by the efforts of the rayon industry to produce synthetic wool. Some of these products are remarkable, and resemble wool in their characteristics, but so far, no synthetic fibre has equalled pure wool as a fibre of commerce. This active production of synthetic wools is largely due to freak economic conditions.

The term wool is applied to the fibrous covering of the sheep, and though other fibres are sometimes described as wool, for example, rabbit wool, the covering of the Angora rabbit, it is technically incorrect. The sheep, either domesticated or wild, is found wherever man resides, except in the extreme northern and southern regions. Our wool supplies come from countries as far north as Iceland, and as far south as Patagonia and the Falkland Islands. If one considers the enormous climatic variations which exist between these

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***Condensed from a lecture prepared for a meeting of the Lancashire Section of the Textile Institute at Rochdale, 7th February, 1940.**

widely separated districts, one can appreciate the great difference between the varieties of wool.

There are over 736,000,000 sheep in the world to-day, which yield nearly 4,000,000,000 (3,827,000,000) pounds of raw wool annually. Many of these sheep, in fact nearly half, produce wool which is of little commercial value, being poor in quality, hair-like in appearance, and of low fleece weight. These native wools are used domestically for the manufacture of crude types of fabrics or carpets, in many cases by hand.

The wool growing areas of the world may be divided into regions, producing wools of characteristic types.

1. *The Fine Wool Producing Regions.*

Fine wool, that is wool of small fibre diameter, classed as 60's and upwards, requires a climate which is equable, with a mean annual temperature of 60° F. to 64° F. and medium rainfall. One such region lies in the southern hemisphere, between 30° and 40° south latitude, and is the most important wool growing region in the world. It includes the important wool growing countries of Australia, South Africa and South America. The second region is in the northern hemisphere, and includes Spain, South of France, Southern Germany, parts of Russia, and parts of the United States of America. It is of interest to note that Spain was the original home of all our fine-woolled sheep.

2. *The Medium Wool Producing Regions.*

Technically speaking the term medium wool refers to the vast amount of crossbred wool which is longer and coarser than the fine wools. Medium wools are produced in districts with mean annual temperatures of approximately 50° F., and a fairly humid climate. The crossbred wool producing regions may be regarded roughly as 45° north and south of the Equator, and include the British Isles, many European countries, parts of the United States of America, New Zealand, parts of Australia, and South America.

3. *The Coarse Wool Producing Regions.*

These are less clearly defined than the other two regions, as most countries, whatever their climatic conditions, produce some low quality and coarse wools. This is particularly so if the districts are mountainous.

Before leaving this brief survey of the geographical positions of wool producing areas, attention may be drawn to our own country which provides a very striking example of the influence of climatic conditions upon the type of wool grown. In the south of England, Down wools which are reasonably fine in quality, are produced and are used for hosiery. In the hilly districts the wools are longer and coarser, and under extreme conditions, as in the Lake District and the Scottish Highlands, the wools produced are low in quality and very variable.

Characteristics of Wool.

Wool is graded according to its quality. Wool quality is a vague term, rather difficult to define. Wool quality in reality sums up the physical and chemical properties of the wool fibre, and determines indirectly its field of application. Wool quality may be said to have two distinct meanings, both of which are of great significance when assessing its value.

1. *Wool Quality. Its Technical Meaning.*

This refers to the count of yarn to which it should spin; for example, wool of 60's quality should spin to 60's, that is 60 × 560 yards per pound. This, however, does not hold true, as most wools will not spin to their quality numbers. The quality number was originally based upon the fibre diameter, and to-day this is the main feature upon which we judge quality, though many other factors play an important part in the actual spinning property of the fibres. The technical meaning of wool quality is of great importance as it enables vendors to describe their wares in such a manner that others may visualise the characteristics of the materials and assess their value. The commercial value is decided not only upon the diameter of the fibres, but also on such properties as length, waviness, uniformity, strength, elasticity, etc.

2. *Wool Quality, Relative Meaning.*

A wool may said to be of good quality if it possesses to a marked extent the features of its type. Thus we may have a coarse diameter wool, which is relatively of good quality, whilst a fine diameter wool may be of relatively poor quality. In this respect the method of appraisement by the wool control is of interest. When submitting wool for appraisement the reputed quality must be stated. The appraisers then give the wool a value in accordance with their opinion as to its possession of the features of its reputed quality or otherwise.

To summarise the term wool quality, one may say that the true quality of a wool is dependent upon its spinning property, which in turn is dependent upon the properties of the material. Briefly these properties may be described as follows :—

1. *Diameter of the Fibre.*

Wools vary considerably in diameter, the coarsest wool grown having a diameter of 1/50", whilst the finest wool grown has a diameter of 1/3500". Diameter of fibre is taken as the basis upon which we estimate the quality of the wool. As the wool becomes finer in diameter its quality increases, thus we have a 28's quality wool with an average diameter of 1/350", whilst a 64's quality wool will have an average diameter of 1/1200".

2. *Length of Fibre.*

This again varies, and may be taken as an indication of quality, but some qualification of this statement is necessary. As wool becomes finer in diameter it normally becomes shorter. Thus a 28's quality wool will have an average length of 14" (maximum), whilst a 64's quality wool will only have a maximum length of 4". Should the length of the fibres increase whilst the other feature remain constant, the value of the wool will increase, as its spinning property will be enhanced.

3. *Waviness of Fibre.*

The waves or crimps per inch which the fibres possess are important in the estimation of the spinning property of the material. Generally speaking the finer the quality of the wools the more waves per inch in the fibre, with an increased spinning property. A 28's quality wool will be straight in fibre, whilst a 64's quality wool will have an average of 24 waves per inch. The formation of the wave must also be considered, regularity of the waves being necessary if the maximum spinning property is required.

4. *Surface Structure of the Fibre.*

Wool is a multi-cellular fibre, the small cells overlapping to form what are called serrations protruding from the surface of the fibre, and giving to different wools their characteristic surface properties. Long coarse wools are composed of larger cells, firmly fastened to the core of the fibre, whilst the cells composing fine short wools are smaller, and give relatively more pronounced serrations. The old theory of spinning was based upon these serrations, but to-day, their importance is not minimised, it is realised that other factors are involved in spinning. There are on the average 80 serrations per m.m. in low quality wools, and an average of 120 per m.m. in the finer qualities of wool.

5. *The Contour of the Fibre.*

The cross-sections of wool fibres vary from circles to ellipses in shape, and this variation, which is common to all qualities of wool, is relatively small. It is logical to assume that the more nearly circular the cross-section of the fibre the better its spinning property, due to the more regular movement and displacement of the fibre, during drafting and particularly twisting.

6. *Strength of Fibre.*

The wool fibre possesses remarkable mechanical properties such as strength, elasticity and resilience. The stronger the fibre the more satisfactorily will it process, due to a decreased amount of fibre breakage, during its passage through the various machines. The strength of the wool fibre varies considerably with the amount of moisture present in the wool, and reaches the greatest value when the wool is dry.

7. *Elasticity of the Fibre.*

Allied to the strength of the wool fibre is its elasticity. This plays a valuable part in the processing of the material, and is a factor which is partly responsible for the durability of the wool fibre. Fibres which are elastic will stretch during processing or wear, and will recover their normal length if allowed to " rest " awhile afterwards. This factor is responsible for an all-wool garment retaining its shape for a longer period than a garment made from a mixture of wool and cotton. Moisture plays an important part in the elasticity of the wool fibre.

8. *Other Features of the Fibre.*

Wool possesses a number of properties, which have some little bearing upon its utility, and may be used as minor guides to wool quality. Among these are colour, lustre and handle. The last may be termed " the layman's quality indicator," for if a wool has a soft handle the layman will usually say it is of good quality, and generally speaking he is correct. One must, however, mention the fact that wools which possess all the other attributes of quality may have a harsh handle. The preservation of this property of handle, must be a consideration during the processing of the material.

9. *The Durability of Wool.*

The wool fibre possesses exceptional durability. This property makes it one of our cheapest fibres in the long run, a factor that has long been recognised. The durability of wool makes it ideal for the manufacture of articles of clothing, soft furnishing fabrics and carpets. With this durability there is also present the property of retaining its shape over a considerable period and recovering from deformation.

The Manufacture of Wool.

The term raw wool refers to wool in the state as it is shorn from the back of the sheep which contains all the impurities acquired during growth. Its manufacture proceeds upon one of two distinct systems of processing, woollen or worsted.

The two systems differ in yarn structure, in the raw materials employed and in the method of manufacture.

1. *Yarn Structure.*

Woollen yarns are composed of fibres which are intermingled, and have a criss-cross arrangement.

Worsted yarns have a completely different structure. The fibres composing this class of yarn are laid as straight and parallel as possible, every endeavour is made to retain the parallelism of the fibres.

The difference in structure is very evident in the finished yarns. Woollen yarns are bulky in appearance, with many protruding fibres on the surface of the yarns. These are of some importance when the resultant fabrics have to be milled or felted, a process commonly applied to woollen fabrics. Worsted yarns appear smooth, lean and straight in comparison with woollen yarns, with few protruding fibres on their surface. In the fabric the yarns again display marked differences. Woollen yarns tend to lose their individuality, whilst worsted yarns retain theirs, even after the operation of milling.

2. *Raw Materials Employed.*

The raw materials of the woollen industry are very varied, ranging from pure virgin wools of short length, which are called "clothing wools," noils, wastes to re-manufactured fibres, these latter being obtained by the tearing up of new or old fabrics. The woollen system of yarn manufacture does not demand length of fibre, as the essential feature. The raw materials of the woollen industry are not confined solely to the wool fibre, as cotton, silk and other fibres are extensively employed. The skill necessary for the satisfactory blending of the fibres is considerable.

The worsted industry generally uses only pure virgin wool as its raw material. Recent years have modified this statement, as to-day, many so-called worsted yarns are produced from blends of virgin wools with synthetic wools, fibro or casein, etc. In addition the demand for novelty in worsted yarns, has caused the worsted spinner to introduce many unusual fibres into his blends.

3. *Methods of Manufacture.*

The woollen and worsted systems differ considerably, as will have been understood from the remarks made upon the difference in yarn structure. In the woollen system four or five operations are necessary to convert the raw material into the spun yarn. The worsted system requires between sixteen and twenty different processes to produce the yarn, the number varying with the type of wool under treatment. The woollen industry is what is termed a centralised industry, that is to say all the operations in converting the raw materials into the finished fabric are generally carried out by the same firm. The worsted industry is what is called a specialised industry, each section of processing being carried out by a separate firm. There are some few exceptions, but it is very rare to find a firm which carries out all the operations, from raw material to finished fabric.

The Manufacture of Woollen Yarns

Sorting. Raw wool is received in the form of a fleece, which may have had the lowest or off sorts removed, termed skirting, and been classed according to its bulk quality and type. The operation of wool sorting is a manual operation, the wool sorter examining the fleeces, and separating the various qualities, according to the requirements of his employer. In the woollen industry, this operation is not generally carried out with the same thoroughness as in the worsted industry.

Wool Scouring. After the wool has been sorted, it is necessary to scour it to remove the various impurities. This process is carried out in exactly the same manner as in the worsted industry.

Wool Drying. This operation consists of the removal of the excess moisture present. The process is carried out as in the worsted industry, and will be dealt with more fully later.

Blending. This is one of the most important operations in woollen yarn manufacture, and is carried out for one or more of the following reasons :—

1. To produce a fabric composed of varying materials.
2. To produce a special colour or effect.
3. To produce a special quality effect.
4. To produce a yarn or fabric at a pre-determined price.
5. To produce a blend capable of spinning to a yarn of the required count or thickness.

The operation of blending may be carried out by various methods, but generally one of the following means is employed :—

1. Piling the different components of the blend in the form of layers, and then commencing to use the completed pile in vertical sections.

2. Feeding the various components of the blend on to the feed sheet of the willeying machine this being carried out uniformly, component after component.

In both cases the materials are finally blended, or mixed, by passing through the willeying machine, which gives them a thorough mixing, every unit of the blend containing the same proportions of the component materials.

Woollen Carding. Generally speaking a woollen carding set consists of two machines, each machine consisting of a series of rollers, covered with card clothing. These rollers gradually open out the blended materials, and finally place them in the form of a thin film of fibres. Connecting the two carding machines, is an intermediate feeding arrangement. This mechanism takes the thin film of fibres, termed a sliver, from the first card, or scribbling machine, and feeds it to the second or condenser card. The transference and feeding of the material is carried out in such a manner, that the fibres are laid crossways into the condenser card.

As the material leaves the last roller of the condenser card, it is split up into a number of small slivers, and passes to the condensing mechanism. At this stage it is rubbed or condensed, by rollers and leathers, which have both a rotary and lateral movement, into a round pith-like thread, termed the condenser roving. The object of this, is to promote some measure of strength in the rovings, so that they will unwind at the spinning operation without breaking. Various types of condenser mechanisms are in use, according to the types of materials being processed. The small rovings are finally wound upon long tin bobbins or spools, in order that they may be transferred to the spinning machine, these bobbins fitting the creels of the spinning machine.

Woollen Spinning. Woollen yarns are almost entirely spun upon the woollen mule, though recent years have seen an introduction of frame spinning, with its increased production. The type of mule employed is one developed from James Hargreaves' spinning jenny, and is very suitable for the spinning of woollen yarns. It utilises spindle draft, which enables a level yarn to be produced. The *modus operandi* may be briefly described as follows :—

1. The condenser rovings are slowly paid out by a pair of delivery rollers, whilst the carriage carrying the spindles moves away from the rollers. The spindles are only slowly revolving, inserting little twist.

2. After the carriage has moved a certain distance from the rollers, the latter stop delivery, whilst the carriage continues to move away. The material is thus drafted out, and whilst being drafted the spindles continue to insert twist. This produces a levelling effect, as the twist, runs into the thin places, making them correspondingly stronger, and thus the thick places draft more readily, until such a time as levelness is produced, when the twist will distribute itself, over the whole length of yarn.

3. When the spindles and carriage reach the end of their outward run the carriage stops, and the spindles continue to revolve at speed, until the requisite amount of twist has been inserted. During this twisting at the head, the carriage usually recedes a little to compensate for the twist take up.

4. The spindles are cleared of their coils of yarn, by the operation of the backing-off mechanism.

5. The yarn is wound on to the cop, as the carriage runs in towards the delivery rollers.

It is interesting to consider the method of twist insertion, this is accomplished by the yarn coiling around the spindle, from the nose of the cop to the tip of the spindle. As the spindle revolves the yarn slips off the tip, and a turn of twist is inserted. This method of twist insertion is extremely efficient and is a development of the old spinning wheel, which inserted twist in exactly the same manner.

The small production of the woollen mule, due to its intermittent action, in comparison with the production obtained with the continuous type of spinning machinery, has led many inventors to attempt to produce a continuous woollen spinning frame. It was only in 1912 that a satisfactory machine was invented, and since that date many improvements have been introduced. This type of machine employs the roller system of drafting, but to achieve the results of a woollen mule, inserts a false twist between the two pairs of drafting rollers. This enables a similar type of drafting to that of the mule to be applied. The yarns produced with this type of machine are usually less elastic than mule spun yarns.

The Manufacture of Worsted Yarns.

Sorting. This operation, as previously explained, is necessary to separate the various qualities which are present in the fleece. The wool sorter requires a long and laborious training in order to become efficient in his work. He largely sorts by visual observation, being guided in his work by the fleece formation, his training indicating to him where the various qualities are usually found in the fleece.

Blending. The objects of blending in the worsted industry may be summarised as follows :—

1. To produce a standard " lot " of material.
2. To produce a blend which will enable a top to be produced, which will sell at a given market price.
3. To increase the processing properties of the material, particularly the spinning property.
4. To produce some special characteristic, which is required in the resultant yarn.

The method of blending most practised in the worsted industry, is the layer method, as previously described for the operation of woollen blending.

Wool Scouring. In its raw state wool contains varying amounts of impurities. These may be as low as 10 per cent., or as high as 75 per cent. Generally speaking, as the wool becomes finer in quality, the amount of impurity increases. Wools from certain districts are always found to have large amounts of certain impurities, due to the nature of the soil and herbage. These impurities may be divided into three classes, according to their origin, as :—

1. *Natural Impurities.* These consist of natural secretions and excretions, which consist of wool fat, wool suint, or sweat, urine and dung.
2. *Acquired Impurities.* These are vegetable and mineral impurities, which have become attached to the wool during its growth.
3. *Applied Impurities.* These may be very varied, and in some cases difficulty may be experienced in their removal. They consist of substances which have been added to the wool, in dipping, branding, etc.

Various methods of wool scouring are in use, but by far the most popular is the emulsion or alkaline system. This system removes the various impurities, with the exception of the vegetable impurities, by the combined action of hot water, soap, and alkali, the material being given sufficient agitation to speed up the operation. It is very important to have scouring solutions of the correct strength. To lessen the amount of the scouring agents employed, it is sometimes found advisable to steep the raw wool in tepid water prior to the scouring proper. In this country it is customary to scour in a set of three to five bowls, the strength of the scouring solution decreasing as the wool becomes cleaner. In recent years the introduction of the *p*H method of control, has done much to improve the efficiency of this operation.

Wool Drying. The wool leaves the last squeeze head of the scouring bowls with approximately 40 per cent. of moisture and after drying it should contain about 25 per cent.

The most popular drying machines in use work on the principle of circulating hot air through the wool. Many types of drying machines are in use, and most of them give satisfactory results.

Preparation for combing.

All the operations are concerned with the straightening out of the fibres, and rendering them parallel. Successful combing is largely dependent upon the correct carrying out of this group of processes. The length of the fibres decides the method of preparation to be used. Two methods are available, carding or preparing, and the line of demarcation between the two methods is not too clear. Generally speaking, wools below 8″ in maximum length are processed on the worsted card, whilst wools over 9″ in maximum length are processed on preparing machinery. Wools 8″ to 9″ in maximum length, may be satisfactorily processed by either method.

Worsted Carding. The objects of this method of preparation are :—

1. To open out the tangled mass of fibres.
2. To straighten out the fibres, and place them in a somewhat parallel relationship.
3. To produce a sliver uniform in all its features.
4. To remove any vegetable matter present.

The worsted card consists of a series of rollers, covered with card clothing. These gradually open out the fibres, and finally deliver them in the form of a sliver. The density of the pinning, and the severity of the treatment, increases as the fibres are opened out. Great care must be exercised in the setting of the various rollers, it being imperative that the length of the fibres is preserved as much as possible. Small fibres may become rolled up, forming what are termed "neps." These must be avoided if possible, and the skill of the carding engineer is largely judged by the freedom of his card slivers from these neps.

At suitable places on the card are placed mechanical burring devices, which either crush or remove any vegetable matter present. Cards are at work to-day which can remove up to 15 per cent. of vegetable matter. Above this amount it is desirable to have the scoured wool carbonised, to ensure that all vegetable matter is destroyed.

Long Wool Preparing. In this series of operations up to six gill boxes, termed preparer gill boxes may be used. The objects of these machines are identical with the objects of worsted carding, except they do not remove vegetable matter. It is not very common to find much vegetable matter in the longer types of wools, any that is present usually drops out at the preparing operations, or else is removed at the comb. The preparer gill box consists of back and front rollers, and a set of fallers in between. These fallers consist of steel bars with two rows of pins, set vertically in the bars. The fallers carry the fibres between the back and front rollers, and are responsible for the opening out of the fibres, in conjunction with the rollers, which apply the draft. It is usual to deliver the fibres in the form of a sheet from the first two machines, and in the form of a sliver from the remainder of the machines in the set, the slivers being delivered into cans.

Backwashing. After the fibres have been opened out, by the preceding operations, it is possible to remove any remaining impurity. This is particularly necessary with the fine short wools, which, due to their compact staple, contain the bulk of their dirty impurity in the tip of the staple. Until this has been fully opened out it is impossible to remove the dirt, without resorting to excessive treatment. Backwashing thus serves a very necessary purpose.

When the carded slivers are fed into the backwashing machine, they are given a mild scour with hot water and soap, passing through two or more bowls. The first of these, is the scouring bowl, whilst the remainder are used for the thorough rinsing of the material. It is customary to add a very small amount of a fugitive blue, in one of the rinsing bowls, in order to enhance the whiteness of the material. After leaving the last squeeze head of the rinsing section of the machine, the slivers enter the drying chamber, where the excess amount of moisture is removed.

Finally the slivers are blended in the gill box. Prior to entering the back rollers of this section of the machine, oil may be added, if an " oil combed top " is desired. This type of top is the normal Bradford top, and will contain 3 per cent. of added oil, usually olive oil, which acts as a lubricant. On the Continent it is customary to employ a " dry combed top," so that no oil is added after backwashing.

Intermediate Gilling. The object of this process is further to straighten the fibres, and produce a more uniform sliver. In recent years a new type of gill box, has become very popular, particularly for the processing of the shorter wools. This is the intersector gill box, which has two sets of fallers, each with one row of vertical pins. The top set of fallers is inverted, and the pins intersect and alternate, with those of the bottom set. This machine gives greatly increased fibre control, and thus produces a more satisfactory sliver, for feeding into the combing machine. The intermediate gilling operations permit the blending of a number of slivers, and thus tend to produce a more uniform sliver, the drafting which takes place, with pin control, assisting materially in the straightening of the fibres, and in the promotion of parallelism.

Combing.

This operation is totally different from any operation in woollen yarn manufacture. A true worsted yarn is one which has been combed. The objects of wool combing are :—

1. The separation of the long, or top fibres, from the short, or noil fibres, the ratio between the two being expressed as the tear.
2. To straighten out the fibres, and so promote parallelism.
3. To remove vegetable matter, neps and slubs.

It is impossible here to attempt to describe the various combing machines in detail, and a brief mention of the different types of wool combs in use must suffice.

The Noble Comb. This is the commonest type of comb in this country, it is suitable for the combing of all types of wools and hairs. It owes its popularity to its simplicity and to its high production.

The French Comb. This comb is used on the Continent. It is particularly suited for the combing of the shorter types of wools, it is capable of being set to give the maximum tear, with a very clear top. It has only a small production when compared with the Noble comb.

The Lister Nip Comb. This was the first of our modern combs to be invented. It has only a limited use, which is confined to the longest wools and hairs. Upon these materials, it has a high efficiency.

The Holden's Square Motion Comb. This is the least common of wool combs, being used only by two or three firms. It is suitable for the combing of medium type and fine wools. It is interesting to note, that this comb follows out the round of movements of the old hand combers in detail.

Top Finishing. The final operation in wool combing is that of top finishing. This operation blends together a number of comb slivers, drafts them and finally delivers the material wound into a ball, which can be considered as the finished product of the wool comber.

Top finishing is carried out by giving the material two, or in some few cases three gillings, using an intersector gill box. During the passage of the material through these machines the standard amount of condition is added, by passing the material over a roller, which is revolving in a trough of water. For oil combed tops the standard is 19 per cent., whilst the standard amount allowed for dry combed tops is 18¼ per cent. The tops are usually examined, before being delivered to the spinner, to ascertain if they are up to standard, and do not contain too many neps or particles of vegetable matter. The comber also carries out repeated tests for the moisture content, and if in doubt the tops will be tested for oil contents and in some cases for residual soap.

Preparation for Spinning.

These operations are concerned with the conversion of the top sliver, into a thin roving, capable of being spun at one operation. They consist of the worsted drawing operations, which may vary in both type and number of processes. Unless worsted drawing has been carried out satisfactorily, spinning cannot be efficient. Irregularities which may arise in drawing, are only increased by any subsequent drawing operations, and in the spinning operation. The number of machines in a set of worsted drawing varies with the material under treatment, and the final weight of roving required. In the case of long wools, which are spun to coarse counts, and therefore need a thick or heavy roving, the number of operations will be as low as six. In the case of fine Botany wools the number of operations may be nine or ten, and if the material be of a mixture type, extra gilling operations may be necessary, to ensure that the various colours are satisfactorily blended.

The objects of worsted drawing may be summarised as follows :—

1. To reduce the thick top sliver to a thin roving.
2. To regularise the reduction, in order to produce a level roving. This is achieved by the running together of two or more ends, behind the back rollers of each machine. This is called doubling, and without this operation it would be impossible to produce a satisfactory roving.
3. To straighten out the fibres, and render them parallel.
4. To promote some measure of strength in the drafted slubbings. This is to enable them to be wound on to bobbins, and unwound at the next operation, without their levelness being affected. In the Bradford system of drawing, this strength is obtained by inserting twist into the slubbings. The Continental system obtains the necessary strength, by condensing the fibres, in much the same way as employed in the woollen industry, at the final carding machine. The Anglo-Continental system achieves some measure of strength by inserting a false twist into the drafted slubbings.

The origin of our drawing machinery is very obscure. It has been established that spinning machinery was first invented, and it is assumed that from our early spinning machinery, drawing machinery was evolved. It is an historical fact, that Richard Arkwright was the first person to introduce some method of preliminary drafting, prior to spinning.

Each system varies in the structure of machines, and in its method of manipulation of the material, and produces a distinctive type of roving.

Bradford System. This system is extremely popular in the English textile industry, being simple in operation, and giving good production. Two distinct types of drawing are included under this system.

1. *Open Drawing.* Open drawing is the commonest system in use for the production of worsted yarns. It inserts twist at every operation after the gilling operations, and this drafting under twist tends to produce a roving, and ultimately a yarn, which is smooth to handle, and lean in appearance. Due to the method of winding-on, which imposes severe strains upon the slubbings,

it is necessary to insert a maximum amount of twist, which again influences the resultant appearance of the yarn. The operations in a set of open drawing are :—

(*a*) *The Gilling operations.* Two or three gill boxes, usually of the intersecting type, are used. The last machine is called the spindle gill box, due to the fact that the material is twisted, by a revolving spindle and flyer, as it leaves the front rollers, and is finally wound on to a bobbin. The bobbin is retarded by felt friction washers, in order that winding-on can be accomplished. The tension placed upon the slubbings, varies considerably with this method of winding-on, which is responsible for the limitation of open drawing to materials of adequate strength.

(*b*) *The Middle Drawing operations.* Open drawing machinery consists of three or four units, identical in design and operation, but due to the slubbings becoming finer in diameter as drawing proceeds, the various parts of the machines are smaller. These machines consist of back and front rollers, which draft the material, and carrier rollers, which control the fibres during drafting ; spindles and flyers, which insert the twist into the slubbings, and wind them on to the bobbins ; and a suitable lifter motion, which ensures that the bobbins are filled over their whole length.

(*c*) *The Final Drawing operations.* Two machines are generally employed but in the case of very fine dram rovings there may be three. They are identical in principle, and very similar in construction, to the middle drawing machinery. Due to the small size of the slubbings or rovings, at the stage in processing, the machines have many more spindles, and run at a much higher speed.

The bulk of modern improvements in open drawing machinery, have been in connection with these operations, and to-day there are many types of final drawing machinery, all of which are designed to give increased production.

2. *Cone Drawing.* The second type of drawing, under the Bradford system, is a development, on more scientific lines, of open drawing. The operations and machines are similar in principle to, but the method of winding-on varies from that of open drawing. Cone drawing was designed for processing wools which have not sufficient strength to withstand the open drawing system. Every endeavour was made to reduce winding-on tension to a minimum. This was accomplished by having a positive drive to the bobbins, and employing the bobbin lead system of winding-on. Drawing takes place with a minimum insertion of twist, a factor which, coupled with the minimum tension imposed, produces a bulky roving of fuller handle than that produced on the open drawing system. Cone drawing, due to its controlled winding-on, is complicated and is only suitable for the processing of large runs of material.

Continental System of Worsted Drawing. This system was devised on the Continent, and is almost exclusively used there for the processing of short and tender wools which the Bradford system could not satisfactorily process. The success of the system is well known, and to-day many plants are working in England, chiefly for the production of hosiery yarns. Whilst fulfilling the objects of worsted drawing, the Continental system is entirely different in structure and operation from the Bradford system. No twist is inserted at any process, which enables pin treatment to be employed at every stage. It is this latter factor which is largely responsible for the efficiency of the system. No other method of fibre control can equal pin control, for the processing of the wool fibre. It is this feature which enables short and tender wools to be processed so satisfactorily. The resultant roving and the yarn produced are very full in handle, bulky, and the yarn possesses features which make it ideally suitable for hosiery or soft handling fabrics.

The gilling operations are of the intersector gill box type, and recent years have seen the introduction of more gilling operations, to the exclusion of some of the drawing. The middle and final drawing operations are similar in principle. The machines consist of creels of special type, back rollers, steel carrier rollers, and the porcupine roller. The last is the distinctive feature of the machines, being a brass roller studded with pins, set at a tangent. These pins enter the material, and control the fibres during the main drafting, that is when the fibres come under the influence of the quickly moving front rollers. After leaving the front rollers, the slubbings are condensed by the action of the rubbing rollers and leathers. These have both a lateral and rotary movement, and rub the fibres into round pith-like structures, giving the necessary strength for winding-on, and unwinding at the next operation. The material is finally wound on to parallel bobbins at the balling head. Full advantage is taken of doubling during French drawing, and drafts are kept low, an equal draft of four being usually imposed at each stage. From the point of view of simplicity no system can equal the French drawing. Its main disadvantage is that dry combed tops are required as the presence of oil in the material would cause the fibres to stick to the rollers, owing to the absence of twist.

Anglo-Continental System of Drawing. This system, which is rapidly growing in popularity, is a combination of the Continental system and the Bradford system. The necessity for this system arose from the demand by many spinners for a system of drawing, mainly on Continental lines, which would satisfactorily process oiled combed tops, and which would produce a roving capable of being spun on normal English spinning machinery. Anglo-Continental drawing fulfils these requirements. The bulk of the machines consist of slightly modified French drawing machines, and the last two operations are of the cone drawing type. The spinner who possesses this type of drawing can spin yarns very similar to those spun on the Bradford system, or can produce yarns somewhat similar to Continental spun yarns.

Worsted Spinning.

The objects of worsted spinning are three in number, being :—

1. To draft the roving to the required thickness or count of yarn.
2. To insert twist as required,
3. To wind the drafted and twisted yarn on to a suitable package, spool, tube, pirn or bobbin.

All types of worsted spinning machinery, draft the roving in the same way, namely, by two sets of rollers revolving at different surface speeds, suitable carrier rollers, placed between the drafting rollers, controlling the fibres during drafting.

The twist is inserted into the yarn, by causing the fibres to revolve on their axis, or in the case of the mule, to slip over the tip of the spindle.

The method of winding-on varies with each system of spinning in use, and constitutes the principal difference between the various spinning machines.

The spinning property of the wool can be directly tested only on the spinning frame.

The humidity of the atmosphere is important in the satisfactory spinning of the material. In the case of dry spun yarns, without the help of added oil, some artificial humidification is essential.

Flyer spinning. This method employs a similar method of winding-on to that in open drawing. It has only a limited application, on account of its low production, and the difficulty of spinning fine counts of yarn. It is used for the spinning of long coarse wools and hairs, and for low counts of yarn from any quality of wool. For the spinning of mohair, this system is the finest possible, its low speed being an advantage, where a smooth lustrous yarn is desired.

Cap spinning. This is the most popular type of spinning in England and in the United States of America, where it was originally invented. The winding-on is accomplished by means of a steel cap, placed at the top of a stationary spindle.

On this spindle is a revolving brass tube, to which the bobbin is attached revolving at a speed of 5,000 to 8,000 r.p.m., which causes the yarn to balloon out around the cap. In doing so it meets with air resistance, which retards it, and enables winding-on to take place, the edge of the cap guiding the yarn to its correct place on the bobbin. Cap spinning has a very high production, and is suitable for spinning very fine counts of yarn. It is used for the spinning of all fine crossbred and merino types of wool, but on account of its high speed, it cannot satisfactorily spin low qualities of wool. The yarns it would produce, with these wools, would be too wild in appearance.

Ring spinning. This method of spinning is not very popular in this country, for the spinning of wool, but enjoys considerable, and growing popularity on the Continent, for dry spun yarns. Its use in this country is increasing.

The winding-on is accomplished by means of a small piece of bent wire, termed the traveller, which fits on the ring in the lifter plate. This traveller provides the necessary yarn tension, to enable winding-on to take place.

One of its disadvantages is that variable spinning conditions arise with a constant speed ring frame. This can be overcome by the introduction of variable speed spinning, using a mechanism called the spinning regulator. For the spinning of wool the limit of the count which can be spun is lower than that on the cap frame.

Mule Ring Spinning. This is a comparatively new type of spinning machine, which has distinct possibilities, and is proving very efficient. It consists of a normal ring spinning frame, with an extended spindle, around which the yarn coils, the revolutions of the spindle causing these coils to slip off the tip of the spindle, and thus insert the twist. This manner of twist insertion is similar to that of the mule, and results in a yarn of loftier handle than that produced by the ordinary ring spinning frame.

Worsted Mule spininng. This is the intermittent system of spinning, and though very efficient, is not very popular, as it can only be employed for the spinning of French drawn rovings, and the mule has a low production compared with the continuous type of spinning machine.

The worsted mule employs spindle drafting, being very similar to the cotton mule in its construction and operation. The twist is inserted by the slip over the tip of the spindle, whilst the carriage is moving away from the rollers. At the end of the outward run, backing-off takes place, and the yarn is wound on the cops during the inward run of the carriage.

The yarns produced in this type of spinning are very full handling, and very regular in their features. Though it will be agreed that the mule is the finest spinning machine in use from the point of view of the material, economically it has many disadvantages.

In conclusion, a few statistics of the Woollen and Worsted industries will convey the magnitude of these industries, and will enable one to realise the importance of wool in the trade and commerce of our country.

Total persons employed in the woollen and worsted industries, approximately		267,000
Total number of combing machines		2,939
Total number of woollen spinning spindles		2,993,000
Total number of worsted spinning spindles		800,000 3,465,000
Total number of looms		98,000
Total weight of woollen yarn spun	lbs.	297,000,000
Total weight of worsted yarn spun	,,	238,000,000
Total area of woollen fabric woven	sq. miles	244,300,000
Total area of worsted fabric woven	,,	160,300,000

(These are the approximate figures for the year 1937.)

Lancashire Section

ANNUAL GENERAL MEETING, 1940

The Annual General Meeting of this Section was held on Wednesday, 13th March, at 6-30 p.m., at the Manchester Limited Café. The Chairman, Mr. W. Howarth, presided over a good attendance. He presented the report of the Section Committee and it was agreed that considering the difficulties arising out of the war the 1939-40 programme of the section had proved very successful.

The following members were unanimously elected to the Committee for a term of 3 years commencing in 1940:—

A. W. Bayes	W. English	F. A. J. Taylor
H. Bromiley	W. Howarth	S. Taylor
T. L. Elliott	R. J. Smith	F. C. Wood.

Mr. W. Howarth then contributed the appended brief remarks. After this meeting the members partook of a Hot Pot Supper and this was followed by an impromptu entertainment. The whole function in view of the black-out, etc., must be considered to have been a very successful one.

TEXTILE TECHNOLOGISTS AND THE WAR

British Industry to-day is frequently referred to as " Fighting on the Home Front " and such a phrase is particularly applicable to the textile industry. Indeed Lancashire and Yorkshire to-day are playing more vital parts than ever in the national economy as well as in their specific war effort.

It is nothing new for us to have to face and to solve new problems. That is our normal daily task and we are trained to that end, but in war time the types of problems are changed. It behoves us to attack them as they arise with vigour, with determination and with persistence.

We call ourselves practical men and we have found by experience that to be sound in practice it is necessary to be sound in theory also. Study and research are essential and we support them wholeheartedly.

We have to organise machines, people and situations, to control the sequence of events so that continuity of production is achieved, and to foresee and to avoid, as far as is humanly possible, those occurrences which might cause a break in the smooth development of our economy.

The new problems created by the war are not to be found in any textbooks. They are already familiar to us and are being solved continuously in various sections of the industry. Of the many problems that arise, markets on a war-time basis, import and export permits and licences, currency problems, war risks, time limits, priorities and price control, may be quoted as examples. Further we have to deal with the inevitable shortage of skilled operatives when expansion of production becomes essential. Black-out arrangements, A.R.P. organisation in the works (and outside), transport facilities, etc., have added to our difficulties.

When it is desirable to keep the cost of the finished article as low as possible in order to avoid inflation, constant watch must be kept on the rising levels of costs in raw materials, wages, stores, etc.

Some reference should also be made to profits. The war coincided with Lancashire's attempt to make a fresh start based upon principles somewhat different from those of the past. That change has not been lost sight of, but it must be subordinated to the war effort. We are no longer fighting for the survival of the industry but for the survival of the nation.

Enormous personal and corporate sacrifices will be required. At such a time profit alone can no longer be regarded as an adequate motive force for industry, or for personal endeavour.

It seems certain that the world will be a changed place after the war. May we not reasonably hope that the work we do and the services we perform will be as essential to society then as now? Our training has been sound, we can adopt ourselves to changing circumstances, and can look forward without fear to whatever lies ahead.

We claim that we are fighting for tolerance, for good will in human relationships, for rising standards of life and morality. So long as we persist in these aims and apply them through our work, our life and actions we are helping to shape that future and we have reason to be proud of it. We have so much that is good to give to the world in peace or war. Let us give it unreservedly.

London Section

The London Section met at the Northumberland Rooms, Northumberland Avenue, W.C.2, on Friday, January 26th, at 6.30 p.m. Mr. Francis Warner was unable to deliver the lecture on " The Development of Oilsilk " owing to the calls of important government work. At extremely short notice Mr. W. A. Dickie, B.Sc., A.I.C., of the British Celanese Limited, prepared a paper on " Some Aspects of Rayon in War Time." The subject was discussed from the economic, technical and commercial points of view and the lecture was well illustrated by means of slides, samples of fabrics, models, etc.

Correspondence

Technical Societies and Their Functions

To the Editor, Journal of the Textile Institute.

Dear Sir,

We shall all agree I think with Mr. J. Schofield in his desire for more rapid progress in the application of economics to textile problems of many kinds and in promoting what he calls " the social results of scientific or technical work," but he will hardly expect the attainment of these abstract ideals without suggestions and action of a much more concrete kind that he has to offer.

It is pertinent to enquire whether the required organisation exist and only need working, or whether the scope of the Institute should be enlarged; and I make bold to say that machinery already exists for the publication and discussion of subjects of economic interest. Perhaps, as in so many things, we get what we deserve. The Institute certainly gets papers and discussions on economics and I cannot believe that publication would be denied to contributions falling within Mr. Schofield's desires, as I would say for the betterment of the industry, whether scientifically, technically or socially.

That there are difficulties to be met, no one will deny. In the field of mental and moral philosophy as in economics, advancement is perforce slower than in the material sciences of engineering and chemistry and some limit must be placed upon excursions into those frequent and inconclusive disputations which concern pure economics and are remote from the textile interest. None the less, I know of nothing, that would be more suitable to the Institute for discussion or would interest so large a number of its members, than the views of economists capable of convincing us that we are lacking in foresight, or just ignorant, in that we pay the little attention we do to such matters.

" Such papers or lectures as may occasionally invade the economic field hardly get beyond mere works costings." This makes me wonder what the writer regards as " economics." Not claiming to be able to state any definition I would suggest that some authorities find many papers already published crammed with economics, although without any such intention. The reader of the Mather Lecture in 1935 was surprised to hear Sir Michael Sadler say that he considered threequarters of the lecture to deal with economics.

But there is a minor point in Mr. Schofield's letter which I can hardly overlook. He tells us that the medical profession, the civil engineers and other bodies have united and powerful organisations safeguarding their interests but that scientific and technical workers are not so represented. I dare not fill your columns by giving an adequate reply to this charge, but must content myself with saying that the Institute certainly looks after the professional interests of scientific and technical workers through National Certificates, Associateship and Fellowship Diplomas and indeed one wonders what more it could do in their interests without trespassing upon the ground already covered elsewhere by trade unions. The machinery exists within the Institute for very many means of progress, but that progress can never be greatly hastened until a far greater number of qualified scientists and technicians are engaged in our industry. The textile industry is very great, but as a whole the industry does not yet appreciate, nor for the matter of that pay for, the talent which alone is essential to its welfare.

The existence of a " united and powerful organisation," safeguarding the interests of its workers, such as the medical profession is said to have, is due of course to the existence of a body of which every single member is qualified by diploma, and where the same interest, subject or employment, is common to all ; and when, if ever, the number of qualified textile technologists is equally great, may be we shall be equally " united and powerful "—but I cannot help wondering how far the medical profession owes its position to the help of the economists. Perhaps they are all unconsciously economists.

(Signed) J. H. LESTER.

General Items

Elections to Fellowship and Associateship have been completed as follows since the appearance of the previous list (February issue of this *Journal*):—

FELLOWSHIPS

WILLIAM HOWARTH
HERBERT LESLIE PARSONS
FRANCIS CARTER TOY

ASSOCIATESHIPS

CHARLES MATTHEW BOTTOMLEY
JOHN VERNER HILL
JAMES DUXBURY SHACKLETON

Institute Membership

At the March meeting of the Council, the following applicants were elected to membership of the Institute:—

Ordinary.

W. H. Butterworth, 11, North View Terrace, High Crompton, Shaw, Oldham (Cotton Spinner).
H. B. Chapman, British Insulated Cables Ltd., Helsby, nr. Warrington (Chief Chemist).
K. Dooley, 36a, Alvenor Street, Ilkeston, Derbyshire (Foreman Hosiery Mechanic).
V. S. V. Iyer, No. 7 New Miranda Buildings, Lady Jamsetjee Road, Dadar, Bombay, India (Weaving Master—Night shift).
G. H. Michell, G. H. Michell & Sons Ltd., 33, Adam Street, Hindmarsh, Adelaide, S. Australia (Company Director).
J. Rouse, R. Dewhirst & Co. Ltd., Bradford Road, Batley (Works Manager).
E. Valko, 94, Cousins Street, St. Johns, Quebec, Canada (Research Chemist).
T. H. Vaughan, Michigan Alkali Co., Research Dept., Wyandotte, Michigan (Director of Organic Research).
R. Yates, 1, Hardlands Avenue, Torrisholme, Morecambe (Textile Chemist).

Junior.

E. A. Bairstow, Sefton Lodge, Baildon, Bradford (Wool Trade).
E. P. Ghadiali, 285, Frere Road, Ballard Estate, Fort Bombay, India (Weaving Assistant).

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PROCEEDINGS

COUNCIL'S ANNUAL REPORT, BALANCE SHEET AND ACCOUNTS FOR 1939.

Presented to the ANNUAL GENERAL MEETING at Manchester, Wednesday, 24th April, 1940.

There is evidence that the Institute is growing in strength from year to year. Every effort has been made to continue the Institute's activities as before though it was feared at the outbreak of war that much of the Institute's work would diminish. On the contrary, however, the work has increased in amount.

Prior to the opening of hostilities the Institute's services had been placed at the disposal of the Ministry of Supply. Our premises and the services of the staff were already being utilised. At the request of Lord Woolton, the General Secretary and two members of the clerical staff were granted leave of absence, Mr. H. L. Robinson becoming Assistant Director of Web Equipment and Webbing Production. Since that time Mr. Frank Nasmith has been Acting Secretary. It will be recalled that the President, Mr. E. W. Goodale, was appointed to the post of Silk Controller.

A Textile Advisory Committee was appointed for the purpose of collaboration in work arising from the national emergency. This Committee has given valuable assistance in a number of cases.

The Balance Sheet and Accounts

In view of the present difficulties the Finance and General Purposes Committee consider the accounts for 1939 to be entirely satisfactory.

Emergency Committee

This Committee was formed at the outbreak of war to deal with questions which required immediate action. Several meetings have been held and much time has thereby been saved.

The Annual Conference at Bath

The Conference held against the historic background of Bath was one of the most successful organised by the Institute. A reception was held at the Grand Pump Room by the Mayor, Capt. Adrian Hopkins, M.C., and a most enjoyable evening's entertainment was provided.

Papers were submitted on various aspects of "New Fibres—their Production, Properties, and Utilization," and lively discussion took place. A special exhibition of new fibres from many parts of the world was arranged. The Mather Lecture was delivered by Professor E. K. Rideal, F.R.S., who gave an interesting and learned paper on "Polymerisation and Its Bearing on the Production of New Synthetic Fibres and Finishes for Textile Fibres."

The Institute Medal

The Institute Medal was awarded to Mr. George Garnett and to Mr. George Moores for their work in the foundation of the Institute and their assistance in furthering its objects over a long period of years. Mr. Moores received his medal at the Conference, while the presentation was made to Mr. Garnett at an interesting meeting held by the Yorkshire Section in Bradford.

The Annual Meeting

A most successful function was held at Leicester. The Midlands Section Committee is to be congratulated on the excellent arrangements which ensured an enjoyable event. After the business meeting lunch was taken, when the Lord Mayor welcomed members of the Institute to Leicester. Dr. E. Wildt, Chairman of the Midlands Section, presided. Members then visited the works of either Messrs. Wolsey Ltd., or Messrs. N. Corah & Co. Ltd., where tea was kindly provided. Later, Mr. E. W. Goodale, who was elected President, delivered his Presidential Address on "The History and Activities of the Silk Association."

Publications Committee and the "Journal"

There has been no change in policy to record. The number of pages in the Proceedings, Transactions and Abstracts Sections were 464, 213 (13 papers) and 816 respectively, and the corresponding numbers in the previous year were 446, 308 (25 papers) and 796. The Transactions Section alone calls for comment. The number of papers accepted is only one half of the number in 1938. It must be admitted that the standard of the contents of this section compares unfavourably with that attained in previous years.

The Publications Committee arranged with the British Association for the Advancement of Science for the production of a series of papers on jute which were prepared for the Dundee meeting. These appear in the September issue.

The new section of the *Journal* in which matter concerning the Standardisation Scheme is published at irregular intervals is referred to in the paragraph dealing with this subject.

The Diploma Committee and Institute Diplomas

The revision of the regulations commenced in 1938 by a special sub-committee under the chairmanship of Mr. J. E. Dalton was completed in 1939. Copies of the new regulations are now available.

For the first time the Institute's Examination in Analysis and Testing of Textile Materials was held in May, 1939. There were 2 candidates, 1 being successful. This examination opens the way for members in the distribution trade to qualify for the Associateship.

The Institute's Examinations for the Associateship Diploma were held as usual in 1939. The Preliminary Examination was held on 17th May, 1939, in Manchester, and the Examination in General Textile Technology was held on 24th May, 1939, at Bradford, Glasgow, Leicester, Manchester, Athens, Bombay, Calcutta, Cawnpore and Madras. In the Preliminary Examination there were 2 successful candidates from a total of 4, and in the Examination in General Textile Technology, 22 candidates were successful from a total of 38.

Applications for the Institute Diplomas during 1939 totalled 85 (21 Fellowship and 64 Associateship) as against 77 in the previous year (14 Fellowship and 63 Associateship). The total number of applications since the Charter was granted in 1925 reached 1,162 (346 Fellowship and 816 Associateship).

Textiles and Designs Committee: Institute Competitions

The number of entries to the Competitions showed an increase on the previous year, and work of a high standard was presented by the candidates. Usually the prize distribution has been held in Manchester, but in view of the difficulties attached to travelling long distances, it was decided to hold area distributions in conjunction with the Sections of the Institute. The prizewinning albums were on view in each centre, and very successful meetings were held. Prizes were distributed by Principal J. M. Holmes at Bolton; Mr. W. Pritchard at Nottingham and Leicester; and Mr. George Garnett in Bradford.

Important developments are taking place with a view to linking the Institute's Competitions scheme with that of the Royal Society of Arts for Bursaries and Travelling Scholarships. The outline of a general scheme of co-operation has been approved by both the Institute and the Society, and it is hoped that a detailed scheme of co-operation will be available shortly.

The total number of entries in 1939 was 171 as compared with 118 in the previous year. Special thanks are recorded to the following firms for gifts of fabrics in connection with the Reference Collection issued this year:—Messrs. British Celanese Ltd., Messrs. Richard Haworth & Co., Ltd., Messrs. John Halliday & Sons, Messrs. Horrockses, Crewdson & Co. Ltd., and Messrs. Tootal Broadhurst Lee Co., Ltd.

The prize money for "E" Competition was given by Mr. P. A. Bentley of Leicester.

H. JAQUES, Esq.
ELECTED PRESIDENT, APRIL 1940

National Certificates in Textiles

There was an increase in the number of candidates over the total for the previous year, indicating the growing strength of the scheme. In 1939 there were 241 candidates for the Ordinary and Higher Certificates; 186 Certificates were awarded, 13 with Distinction. Seventy courses are now recognised in 27 Colleges and Schools.

Section Activities

Section programmes had every appearance of increasing strength, but with the outbreak of war, blackout conditions created difficulties. During the winter of 1939, meetings were held by the Lancashire, London and Yorkshire Sections. In spite of the bad weather and war conditions, attendance at lectures has been good. All sections hope to continue with programmes during the coming year. The following section meetings were held in 1939:—

Irish Section, three meetings; Lancashire Section, ten meetings (one visit); London Section, four meetings (one visit); Midlands Section, three meetings (one visit); Scottish Section, one meeting; Yorkshire Section, eight meetings.

A new section in the Macclesfield, Leek and Congleton district was formed after much enthusiasm had been shown by members in this area. However, it is now thought best to wait until conditions are more normal before the new section begins to function in a practical manner.

Editorial Board

It will be recalled that the decision to set up an Editorial Board was announced during the Conference at Peebles. Three meetings were held in 1938 and four in 1939, but the outbreak of war interfered with the work. Definite arrangements for the first publication of the Board have been concluded and plans for others are now well advanced. The Board realizes that rapid progress is not possible. It is acknowledged that the production of handbooks in which the shortcomings of the past are avoided will not prove an easy task.

Employment Bureau

This branch of the Institute's work is still being maintained. In view of the number of enquiries received it is felt that the employment bureau is meeting increased recognition.

Standardisation in Textiles

The development of the Institute Scheme for Standardisation in Textiles has pursued the expected course. On the administrative side the outstanding event was the setting up of the Textile Divisional Council, the fourth section of the organisation of the British Standards Institution. The Technical Committees have been able, despite the dislocation due to the war, to issue through the Unification of Testing Methods Committee for consideration and comment, the first tentative textile standards. The suggestions for amendment which have been received indicate that the scheme is on a very satisfactory foundation. Standardisation Sections of the *Journal* appeared in June and October, 1939, the June number containing a report covering the period from the beginning of the scheme to the end of 1938.

Council and Committee Meetings

The following is a record of meetings held during 1939:—Council, 10; Finance and General Purposes, 10; Emergency, 5; Publications, 11; Development, 2; Diplomas, 10; Joint Committee, *re* National Certificates, 3; Textiles and Designs Committee, 6; Scholarships, 2; Conference, 1; Unification of Testing Methods Committee, 7; Editorial, 4; Yorkshire Section, 2; Irish Section, 1; Midlands Section, 1; Lancashire Section, 3; London Section, 2; and Scottish Section, 1. In addition, 3 Sub-Committees met for the consideration of special matters.

The total number of meetings for 1939 was 81, as against 85 in the previous year.

Membership

The membership list at the end of 1939—to be carried forward to 1940—was made up as follows:—Honorary Members, 11; Life Members, 52; Ordinary Members, 1,545; Junior Members, 149; Total, 1,757, as against 1,711 at the end of 1938. Of the numbers at 31st December last, 194 had been admitted to the Fellowship and 425 to the Associateship.

The Council regrets to announce the loss by death, during 1939, of many prominent members, including the following:—A. B. Ball (London), J. P. Beveridge (Perth), E. E. Blake (Maine, U.S.A.), A. T. King (Leeds), R. Kirk (Leeds), Paul Krais (Germany), C. W. Leather (Cleckheaton), W. W. Lee (Heywood), A. Pollitt (Manchester), H. D. Roberts (Canada), and P. B. Whitehead (Manchester).

The Textile Institute—Balance Sheet as on 31st December, 1939

Dr. | Cr.

LIABILITIES

1938 £ s. d.		£ s. d.	£ s. d.
	Foundation Fund—		
11922 11 4	General Account	11924 11 4	
5500 0 0	Cotton Reconstruction Board Grant	5500 0 0	
2500 0 0	Crompton and Beanland Prize Fund	2500 0 0	
787 15 3	Life Membership Reserve Account	829 15 3	20754 6 7
	Scholarship Scheme Reserve Account—		
	Balance as on 31st December, 1938	265 16 11	
265 16 11	*Add* Surplus Income over Expenditure for Year	177 16 2	443 13 1
	Crompton and Beanland Prize Fund Scheme Reserve Account—		
– – –	Balance as on 31st December, 1938	5 7 10	
5 7 10	*Add* Surplus Income over Expenditure for Year	25 19 2	31 7 0
205 17 9	Standardisation Scheme Reserve Account		– – –
	National Certificates Scheme—		
– – –	Balance as on 31st December, 1938	40 17 9	
40 17 9	*Add* Surplus Income over Expenditure for Year	30 5 8	71 3 5
67 6 6	Subscriptions Paid in Advance		28 9 4
591 6 9	Sundry Creditors and Reserves		654 16 6
935 3 2	Bank Overdraft—General Account		1345 16 6
£22822 3 3			£23329 12 5

ASSETS

1938 £ s. d.		£ s. d.	£ s. d.
	Furniture, Fittings and Library Account—		
	Balance as on 31st December, 1938	280 9 10	
	Additions during Year	54 10 6	
		335 0 4	
280 9 10	*Less* Depreciation	106 12 5	228 7 11
	Investments Account (See Schedule)—		
11513 0 9	Foundation Fund	11513 0 9	
5502 13 3	Scholarship Scheme	5502 13 3	
3515 1 0	Crompton and Beanland Prize Fund	3515 1 0	
252 10 0	Life Membership Account	252 10 0	20783 5 0
– – –	Sundry Debtors	513 8 6	
374 4 7	Journal Account—Outstanding Adverts.	296 10 7	
72 11 1	Do. Outstanding Reprints	77 1 6	
– – –	Do. Standardisation Account	171 11 3	
11 5 0	Do. Crompton Prize Fund—Income Tax Repayment due	– – –	1058 11 10
77 8 1	Pension Fund—Unexpired Premiums		43 15 7
68 7 2	Cash on Deposit—York County Savings Bank		80 13 3
	Cash at Bank—		
223 9 6	Standardisation Account	– – –	
331 15 0	Special Schemes Account	597 3 4	597 3 4
9 10 0	Gas and Electricity Deposits		9 10 0
13 16 9	Cash in Hand		14 9 0
	Revenue Account—		
– – –	Balance as on 31st December, 1938	576 1 3	
576 1 3	*Less* Surplus Income over Expenditure for Year	62 4 9	513 16 6
£22822 3 3			£23329 12 5

AUDITORS' REPORT TO THE MEMBERS.

We report to the members that we have examined the above Balance Sheet, together with the books and vouchers of the Institute, and that we have obtained all the information and explanations we have required. We further report that in our opinion the Balance Sheet is properly drawn up so as to exhibit a true and correct view of the state of the Institute's affairs according to the best of our information and the explanations given to us, and as shown by the books of the Institute.

37 York Street, Manchester, 1.
1st *April*, 1940.

Signed H. JAQUES, *Chairman.*
W. W. L. LISHMAN, *Hon. Treasurer.*

ARTHUR E. PIGGOTT, SON & CO.,
Incorporated Accountants, Auditors.

Journal Account for the Year ended 31st December, 1939

Dr.

1938 £ s. d.	EXPENDITURE	£ s. d.
2271 11 2	To Printing and Blocks	2140 11 6
406 6 1	,, Salaries	191 7 0
141 19 7	,, Wages	112 14 5
346 4 7	,, Distribution	351 14 6
129 5 7	,, Reprints	52 6 5
19 6 4	,, Literary Contributions and Abstracts	6 0 1
176 1 10	,, Advertisement Commission	136 5 7
120 5 2	,, Rent and Rates (Proportion)	123 5 5
35 16 4	,, Heating, Lighting and Cleaning (Proportion)	45 14 8
69 9 5	,, Postages, Telephone and Telegrams	48 17 5
46 11 0	,, Travelling Expenses	50 7 11
41 1 6	,, Stationery	19 17 0
£3803 18 7		£3279 1 11

Cr.

1938 £ s. d.	INCOME	£ s. d.	£ s. d.
1287 12 11	By Advertisements		1163 7 2
951 5 3	,, Journal Subscriptions		915 5 2
	,, Special Subscriptions—		
185 0 0	Linen Industry Research Association	178 15 0	
21 0 0	Wool Industries Research Association	21 0 0	
			199 15 0
	,, Annual Donation—		
10 10 0	The Clothworkers Company		10 10 0
149 18 8	,, Reprints		80 19 1
2605 6 10			2369 16 5
1198 11 9	,, Transfer from Membership Subscriptions		909 5 6
£3803 18 7			£3279 1 11

Foundation Fund

Income from Investments Account for the Year ended 31st December, 1939

Dr. Cr.

1938 £ s. d.	EXPENDITURE	£ s. d.	1938 £ s. d.	INCOME	£ s. d.
	To Allocations—			By Income from—	
25 0 0	Mather Lecture	25 0 0	22 2 6	£1000 0 0 3% Leeds Corporation Redeemable Stock *less* Tax	21 15 0
378 12 5	Revenue Account—General	352 17 6	12 12 2	£569 15 0 3% Local Loans *less* Tax	12 8 0
37 15 10	Life Membership	37 15 10	36 13 1	£1242 10 0 4% Consols *less* Tax	36 0 8
183 1 2	Scholarship Scheme	182 17 0	1 3 10	£47 19 6 2½% Conversion Stock *less* Tax	1 3 10
68 3 9	Crompton and Beanland Prize Fund	89 7 6	33 3 9	£1125 0 0 4% L.M.S. Preference Stock *less* Tax	32 12 6
			29 0 0	£1000 0 0 4% Funding Loan *less* Tax	26 0 0
			557 17 10	£15939 18 10 3½% War Stock	557 17 10
£692 13 2		£687 17 10	£692 13 2		£687 17 10

Crompton Prize Fund Scheme—Competitions

Income and Expenditure Account for the Year ended 31st December, 1939

Dr. Cr.

1938 £ s. d.	EXPENDITURE	£ s. d.	1938 £ s. d.	INCOME	£ s. d.
16 6 4	To Printing and Stationery	31 0 3	130 13 0	By Albums Subscriptions	131 14 0
6 15 0	,, Purchase of Specimens	10 0 1	11 15 9	,, Competition Entrance Fees	18 3 0
11 15 0	,, Mounting of Specimens	27 11 6	5 0 0	,, Donation—Norman Pollard (1938), P. A. Bentley (1939)	12 0 0
161 14 2	,, Prize Awards and Expenses	150 4 3	35 0 0	,, Dividend on £1000 3½% War Stock	35 0 0
9 19 2	,, Postages and Carriage	12 1 9	– – –	,, Dividend on £1000 3% Leeds Corporation Redeemable Stock	21 15 0
15 0 0	,, Administration Expenses	15 0 0	33 3 9	,, Dividend on £1125 4% L.M.S. Preference Stock	32 12 6
221 9 8	Total Expenditure for Year	245 17 10	11 5 0	,, Income Tax Repayment	20 12 6
5 7 10	,, Revenue Account—Surplus for Year	25 19 2			
£226 17 6		£271 17 0	£226 17 6	Total Income for Year	£271 17 0

Scholarship Scheme

1938 £ s. d.	EXPENDITURE	£ s. d.	1938 £ s. d.	INCOME	£ s. d.
121 0 0	To Scholarship Holder's Maintenance Allowance (1938)	– – –	170 9 0	By Interest on £4870 3½% War Stock	170 9 0
100 0 0	,, British Cotton Industry Research Association	– – –	12 12 2	,, Interest on £569 15 0 3% Local Loans	12 8 0
5 0 0	,, Administration Expenses	– – –			
4 5 8	,, Printing and Stationery	5 0 10	183 1 2		182 17 0
			47 4 6	,, Reserve Account—Excess Expenditure (1938)	– – –
230 5 8		5 0 10			
– – –	,, Reserve Account—Surplus Income (1939)	177 16 2			
£230 5 8		£182 17 0	£230 5 8		£182 17 0

Dr. The Textile Institute—Revenue Account for the Year ended 31st December, 1939 Cr.

1938 £ s. d.	EXPENDITURE	£ s. d.	£ s. d.
240 10 4	To Rent and Rates	369 16 3	
	Less to Journal Account and Standardisation Account	163 5 5	206 10 10
71 12 9	,, Heating, Lighting and Cleaning	137 4 0	
	Less to Journal Account and Standardisation Account	60 14 8	76 9 4
912 14 7	,, Salaries	1316 4 6	
	Less to Journal Account and Standardisation Account	391 7 0	924 17 6
449 2 10	,, Wages	693 8 1	
	Less to Journal Account and Standardisation Account	291 14 1	401 14 0
88 10 9	,, Pension Fund Contributions		91 17 7
52 10 0	,, Savings Association Contributions		47 5 0
130 19 2	,, General Expenses		106 1 7
173 7 11	,, General Printing and Stationery		120 1 9
146 16 0	,, Postages, Telegrams and Telephones		108 2 9
11 8 1	,, Insurances		7 7 2
45 10 0	,, Audit and Legal Charges		174 14 9
21 0 0	,, Subscriptions to Institutions		29 1 0
46 7 0	,, Painting and Decorating		– – –
88 5 0	,, Income Tax		– – –
94 3 2	,, Depreciation on Furniture		101 2 0
193 18 7	,, Section Expenses		148 4 1
246 19 11	,, Annual Conference Expenses		186 7 8
100 12 10	,, Meeting and Travelling Expenses		56 7 3
70 2 0	,, Library Account		26 19 9
– – –	,, Editorial Board		4 3 11
47 19 1	,, Diplomas Account Expenses		103 17 6
2 9 9	,, Medal Account		2 11 6
200 0 0	,, Grant to Standardisation Account		50 0 0
– – –	,, Bank Charges, *less* Interest		4 12 8
3434 19 9			2978 9 7
– – –	,, Surplus Income over Expenditure for Year 1939 ...		62 4 9
£3434 19 9			£3040 14 4

1938 £ s. d.	INCOME	£ s. d.	£ s. d.
2700 1 6	By Membership Subscriptions (1939)	2927 5 0	
165 2 6	,, Paid in Advance in 1938	67 6 6	
157 12 7	,, Arrears	215 1 6	
21 0 0	,, Special Subscription—The Weavers Company ...	21 0 0	
37 15 10	,, Interest on Life Membership Investments	37 15 10	
164 18 0	,, Diploma Fees	213 13 6	
3246 10 5		3482 2 4	
1198 11 9	*Less* Amount transferred to Journal Account ...	909 5 6	
2047 18 8			2572 16 10
120 0 0	,, National Certificates, Competition and Scholarship Schemes—Administration Expenses		115 0 0
7 0 3	,, Bank Interest *less* Charges		– – –
378 12 5	,, Foundation Fund Income from Investments Account		352 17 6
2553 11 4			3040 14 4
881 8 5	,, Excess Expenditure over Income for Year 1938 ...		– – –
£3434 19 9			£3040 14 4

Total Arrears as at 31st December, 1939 ... ... £515 19 0

THE TEXTILE INSTITUTE

SCHEDULE OF INVESTMENTS

(at Cost or Value at Original Date of Gift) **as on 31st December, 1939**

FOUNDATION FUND.

				£	s.	d.	£	s.	d.
General Account—									
£3737	14	9	3½% War Stock	3503	7	0			
4789	9	5	Do	4789	9	5			
48	16	3	Do.	49	14	1			
105	5	3	Do.	106	14	0			
102	17	6	Do.	105	16	0			
240	0	0	Do.	246	10	9			
650	0	0	Do.	661	9	6			
194	9	2	Do.	200	0	0			
1000	0	0	4% Funding Stock, 1960-90	800	0	0			
1242	10	0	4% Consolidated Stock	1050	0	0	11513	0	9
Scholarship Scheme—									
£4870	0	0	3½% War Stock	5002	13	3			
569	15	0	3% Local Loans	500	0	0	5502	13	3
Crompton and Beanland Prize Fund—									
£1000	0	0	3½% War Stock	1000	0	0			
1125	0	0	4% L.M.S. Railway Pref. Stock	1500	0	0			
1000	0	0	3% Leeds Corporation Redeemable Stock, 1955-58	1015	1	0	3515	1	0
Life Membership Account—									
£52	5	0	3½% War Stock	53	14	6			
50	0	0	Do.	51	5	6			
99	1	6	Do.	97	10	0			
47	19	6	2½% Conversion Loan, 1944-49	50	0	0	252	10	0
£20925	3	4	*Nominal Value*				£20783	5	0

The Market Value of the above Securities on
31st December, 1939, was approximately £19,255 17s. 2d.

(Securities at National Provincial Bank Ltd.)

Audited and found correct

37 York Street, Manchester, 1.

ARTHUR E. PIGGOTT, SON & CO.,
Incorporated Accountants, Auditors.

1*st April*, 1940.

THE FUTURE OF TECHNICAL TRAINING AND THE COTTON INDUSTRY*

By J. READ.

The present position of technical training in the cotton industry is one of acute depression. In common with the decline in size of the industry, we have seen during the past eight or ten years, a steady fall in the number of students enrolled in textile classes. But textile instruction has declined at a greater rate than the industry because for many years young persons have avoided entry into cotton mill life. The industry has had a reserve of older operatives upon which it could draw to keep the mills running. The impression has been forced upon young people that there are no prospects of a decent and steady job in the industry. Short-time working, slow promotion, relatively poor wages, and the great reluctance of Lancashire parents to send their children into the mill, have inevitably turned them to seek employment in other spheres. Rightly or wrongly, the cotton industry has always demanded that a child shall enter the mill at the earliest possible age it is permitted to leave school, and in recent years, due to the changes in educational policy, this has meant that the mills have had a sort of third selection from those passing out of elementary schools. The brightest pupils have passed on to the secondary schools, the next to the junior technical and central schools, and the remainder, consisting of those who are not likely to profit by further education, or whose parents cannot afford it, are available for the mills.

Mill life is most unpopular with the younger generation and it is taken up only when every other avenue of employment is closed to them. This reluctance is, in my opinion, not fully justified ; for I believe that working in a spinning or weaving mill is, or ought to be, just as healthy, as profitable, and as adventuresome in making a career, as most of the other occupations available for the mass of young people. I venture to say that there are more " blind-alley " jobs outside the cotton trade than there are inside. However, the fact remains that there are no young people available for the cotton industry, not even for essential war work.

The cotton industry was the chief exporting industry of this country and it is still one of the most important. In the past, it has poured great wealth into the state, and we cannot afford as a nation to allow its decline to continue. It is our duty to preserve what is left and to endeavour by all the means available to revive it ; to make it a healthy, living organisation in which every person connected with it shall be proud.

There are many important factors which have contributed to the decline of the cotton industry, and most of them are not the responsibility of the industry itself, much less are they the responsibility of the technical colleges. The industry has been maligned as inefficient and obsolete, when in fact it has all the time been most efficient, and has been staffed with well-trained leaders, managers, foremen, and by skilful operatives. It has been the part of the technical colleges to train people for responsible posts in the mills and warehouses, and this training was so popular that there was always a surplus of certificated men working as ordinary operatives, but capable of holding more responsible positions. The supply was so much greater than the demand that many trained men have gone abroad and have been instrumental in establishing cotton industries in other lands.

The necessary technical training to produce the managers and foremen has always been quite voluntary on the part of the ambitious youth. He has followed it through at his own expense, and in his spare time. The great majority of employers have, in the past, been quite indifferent about it, and the trade unions have not considered it any part of their business to assist or encourage their members in that direction. So great has been the indifference in some quarters that it has amounted to definite opposition, and we may have wondered if the industry really did require technically trained men. However, in the places where managers and foremen are wont to congregate, we are accustomed to hear them declare, with a measure of pride, that they attended this or that school, gained their Full Technological Certificate in such a year, and perhaps best of all, a silver medal in such a section of study. Most of the people in responsible positions today, just as was the case twenty or more years ago, have graduated through the mill and the technical college.

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* A paper contributed as the opening of a discussion at the meeting of the Lancashire Section of the Textile Teachers' Association, Saturday, 6th April, 1940.

It is essential for the industry to have these trained men, and it requires them in greater numbers than ever before in its history, because of the diversity of materials now employed and the greater variety of fabrics produced. We have mentioned that the industry carried a surplus of trained personnel in its prosperous days. But what is the present position?

Let us assume there are about 35,000,000 spindles and 400,000 looms at present, and that the average size of a spinning mill is 80,000 spindles and that of a weaving shed 800 looms. There are roughly, about 440 spinning mills and 500 weaving sheds. Each spinning mill should have five trained men who have received the best possible technical training and should be holders of the Full Technological Certificate, or the National Certificate, or better still, the Associateship of the Textile Institute. I place such men as the manager, under-manager, spinning overlookers, carders, preparation overlooker and salesman in this class. On the weaving side the number is more difficult to estimate because the nature of the work varies considerably. In the simplest type of mass-production grey mill, there should be at least three certificated men, while the number will be increased as the type and quality of cloth and the necessary equipment to produce it becomes more complex. We may require eight or ten certificated men holding responsible positions ; managers, salesmen, head overlooker, designer, preparation overlooker, costing clerk, warehouseman, shed manager, jacquard foreman, and many others whom you can detail according to circumstances. Let us assume an average of five certificated men per weaving shed, then,

Estimated certificated men in Cotton Spinning, 2,200 to 2,500.
Estimated certificated men in Cotton Weaving, 2,500 to 2,700.

Suppose the average working period is twenty years, then the average annual demand for certificated men would be roughly, 110 to 130 for spinning and about an equal number for weaving.

Last session, the number of candidates in the final year (5th year) in the City and Guilds examinations in Cotton Spinning and in Cotton Manufacture (Weaving) was, Spinning 41, of whom 24 passed, and Weaving 72, of whom 53 passed.

The number of students presenting themselves is not sufficient to maintain efficient technical control of the industry. But remember that this training is quite voluntary on the part of the student, and is no guarantee of their securing any material advantage. The colleges should be receiving a steady enrolment of 500 to 700 students each session, both for spinning and for weaving in order to supply this trained personnel under present conditions of working.

How can a closer co-operation between the industry and the colleges be brought about? I would suggest that in the first place the employers and the trade unions should recognise in some tangible form the qualifications which student-operatives work so hard to obtain. Is it too much to expect that every man holding a responsible position in the mill *shall be a certificated man,* and that this shall be the first qualification he must possess before he can, by regulations, hold his job? This may appear to be a drastic regulation to introduce, but is it any more drastic than the conditions which already exist in connection with the craft-unions? A youth cannot take up a particular line of craftsmanship in the factory unless he is first admitted a member of the union, and if he has no special connection with a member, or members of that union, he has the greatest difficulty in becoming a member. Here indeed, is control which the employer is forced to accept, and one which does not always provide the best man to fill the vacancy.

Craft unions are descendants of the ancient guilds which controlled the employment of apprentices, and the indentures usually stated that the youth would be trained for his job, and when he reached the stage of a skilled craftsman, he would be admitted into full membership of his craft. The craft-unions should revive their interest in the training of their members, supplementing the practical mill work, which is specialised and yet varied, according to the type of factory in which they are employed, by a wider training in their job, which is the function of the technical college to provide. For example, it is estimated that there are about 6,000 loom overlookers in regular employment, and probably there are 300 new entrants into this craft each year. In some cases the colleges are working in close contact with the local unions of overlookers and very good results are obtained. Why should this good work not be extended and fully recognised by all concerned. You can apply this principle to each type of craftsman in the industry and none can deny that great advantages would be secured.

There is another side of the industry in which special technical training is very essential, but which is almost entirely neglected ; the training of salesmen and representatives for home and overseas markets. When all is said and done, we are all working on one job, the production of a finished piece of cloth, and we all live on the sale of that article. Our representatives should be technically trained men, not, of course, mechanical experts but fabric experts, persons who can interpret native requirements in design, colour, texture, quality, price, in such a manner as to enable the materials to be made quickly and accurately. We have evidence that men who are trained in fabric technology can increase volume of trade. If the Government is serious in its intentions to foster and increase our export trade, I believe the campaign will have to be in the nature of a missionary enterprise. We must have men properly trained to study market requirements, and also know all there is to know about the goods they are selling. I believe we have lost a good deal of trade because our competitors have had such men on the spot, keen, alert, and ready to consider any proposition that has been put before them. We have had experience in training such men, but I must tell you that we had several groups of foreign salesmen before a British firm thought there was anything of value to be gained from technical training in fabrics.

What can be done about the young people and the future of the industry? The surplus of trained operatives which has existed for many years is now exhausted, and there is a definite shortage of labour. Promotion for young men ought to be substantial and rapid in the near future, but there seems to be a sort of inferiority complex prevailing, which it is our first duty to remove. How can we break down the general prejudice which exists against the industry, and create a lively interest in the minds of young people? I believe the avenues of approach must be changes both by the schools and the trade. For example, is there any reason why junior technical schools should concentrate their teaching upon turning out boys for engineering workshops and drawing offices, or for the building industries, while the textile industries are never mentioned except from an historical point of view as being the chief instigators of the industrial revolution? Can a boy be trained equally well to control hand and eye in textiles as in the other trades? If textiles were introduced in such schools, is the industry on its part, willing to engage those so trained on an apprenticeship basis?

Some of our methods of recruitment are relics of the early days of power-driven machinery, and even go back to the hand-loom weaving days of 150 years ago. The staffing of a mule spinning room, to take a case, with its minders, big and little piecers, creelers, etc., is reminiscent of the days when the mule spinner brought in the available members of his family to assist him run the mule, and he received the family wages for the job. In some districts it is still the custom for a child who wishes to become a weaver, to start as a " learner " without wages, and be trained by some philanthropic operative who also receives no payment for teaching the child. As you know, the next step is for the youngster to become a " tenter " or helper to some other weaver at that weaver's expense, so that in effect, the employer is presented after a period of six or twelve months, with a trained weaver at no expense to himself. Surely such methods are not going to attract young people today. Why should a boy on entry be placed in one section of a mill and be expected to spend the rest of his life in that section? Cannot we devise some form of apprenticeship which will take a lad through the mill and let him in that time, find which job best suits his inclinations? Let him be sent to a day or evening school to study the whole of the craft of spinning or weaving, and he will quickly realise that this vast industry has so many points of interest that he will become fascinated with it.

The more enterprising weaving mills now have their training rooms for young operatives, and they are given a weekly wage from the day they enter, but all factories cannot do this. I do not see why the schools cannot be organised to do such work. There is something to be said for the continental method of organising a technical school to produce yarn or cloth in the finished state, to be sold on a commercial basis, particularly if applied to the training of young operatives.

In conclusion, I believe that the time has arrived when the industry and the colleges must together seriously consider the questions of technical training and recruitment of young people, particularly boys and girls of a high standard of intelligence.

London Section

"THIS IS COTTON SHRINKAGE"*

By Geo. F. Young, The Bradford Dyers' Association, Ltd.

Under the above title, the lecturer gave an account of the process of controlled mechanical shrinkage known to the industry and the public as the "Rigmel" finish.

The Reason and Necessity for Mechanical Shrinkage

By quotations from researches by the British Cotton Research Association ("Fundamental Principles that govern the Shrinkage of Cotton Goods by Washing." G E. Collins. *J. Text. Inst.*, 1939, 30, p. 46), Mr. Young demonstrated that agitation of a cotton fabric during washing was an important factor in releasing strains due to processing, and that such agitation had usually to be repeated in several washings before minimum size was reached. Commercially, it was clearly impossible to reach this minimum size by methods which confined themselves mainly to the effect of moisture, e.g., the methods described in the trade as "natural" shrinkage. Mechanical shrinkage, by introducing accurately controlled lateral compression, accomplished a close approximation of the effect of those repeated agitations.

Mr. Young pointed out that the quotations he had given explained "the popular fallacy that laundries are responsible for shrinkage. In the great bulk of cases," he said, "the more efficient cleansing procedure of the laundry merely disclosed latent shrinkage more suddenly." At a later stage in his paper, however, he reported that from a survey of laundry practice it appeared that in respect of shrinkage one or two laundries in every ten differed from the normal.

Wash-Testing

Mr. Young turned next to the wash-test procedure used in controlling mechanical shrinkage. No standard practice existed. Every testing house had its own method, and some of these were elaborate, costly and absorbed much time.

This made it necessary for the Bradford Dyers' Association when they introduced mechanical control in 1931, to evolve a practical testing method. Laundries in various parts of the country were used to discover what on the average was the result of their every-day practice.

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* Summary of a lecture to the London Section of the Textile Institute, 16th February, 1940, T. C. Petrie, Esq. in the chair.

"Finally," said Mr. Young, "we based our operations on what laundries as a whole actually *did* to cloth, not what they could do, or should do, or might do. We endeavoured to be realists, not theorists."

Two facts emerged:—

(1) Whatever was done, no commercial shrinkage could apparently be 100 per cent. efficient until every laundry throughout the country could be relied upon to produce on a garment exactly the same result as every other laundry. As noted above, of every 10 laundries, two varied from the normal in their effect on a cloth.

(2) No single wash-test could possibly satisfy the actual needs of all types of cotton fabrics. Overalls, shirts, and furnishing fabrics had different lives. Also, the effects of drying, pressing and ironing were not the same for all classes of fabric.

As a result of experience, Rigmel wash-testing to-day was graded on the basis of "Fitness for purpose" to approximate to the actual needs of the various garment groups. It avoided theory on the one hand, and it was not an arbitrary wash-test for all fabrics on the other.

Since the Rigmel process was first applied, many thousands of tests had been made. No other organisation, commercial or scientific, had a comparable volume of experience of British cloths and British conditions in this respect. The result was, that out of every 1,000,000 garments made to-day from "RIGMEL" shrunk cloth only five found their way back to the Bradford Dyers' Association as complaints.

After a brief description of the process for the benefit of those not already familiar with it, Mr. Young emphasised the importance of the check-testing procedure *after* shrinking, which he described as "in effect, an additional laundering." If any further shrinkage existed in the cloth it would be disclosed at this stage and steps would be taken "to investigate the habits of that particular cloth more intimately."

Co-operation by the Maker-up

It has been claimed that "naturally" shrunk cloth had the advantage of resisting stretch during making-up. Mr. Young quoted at length from experiments on this subject conducted by the Shirley Institute, demonstrating the misleading nature of this claim.

Explaining the technical reasons for the relatively extensible nature of a shrunk cloth, Mr. Young pointed out that, in an unshrunk cloth, the yarns, having been stretched during processing, lay in relatively straight paths. They were tightly pulled against one another and no space existed between warp yarn and weft yarn or between the individual fibres. When cloth is wetted, the fibres swell and need more room. The yarns become thicker and the warp requires more space to enable it to pass over and under the similarly thickened weft yarn. Instead of having a relatively straight path it now has to follow a longer and more undulating path. Hence the cloth shortens. Or to use the common term, it shrinks.

When the cloth is dried again the swollen fibres resume their original dimensions, leaving free space between them. Similarly, the yarns decrease in diameter, and free spaces are left in the cloth structure. As no tension exists to pull out the cloth again to its unshrunk length, the structure of the fabric remains loose. Consequently, the resistance a maker-up is accustomed to meet in unshrunk cloth is not present. If he imposes tension on the shrunk cloth, however unintentionally, there is nothing to resist the tension until the free space has been reduced by a re-stretching of the cloth.

The extensibility is thus not due to the method of shrinking. But it is closely related to the degree of shrinkage given to the cloth. If it is claimed that a "naturally" shrunk cloth can be handled with less care than a "mechanically shrunk" cloth, the conclusion may fairly be drawn that this is merely because the "naturally shrunk" cloth is not fully shrunk, and should therefore not have been offered as such.

Incorrect ideas concerning mechanical shrinkage used to exist amongst makers-up on this subject, but now that the technical facts are becoming known, less adverse criticism was heard each year. It was now widely realised that certain practices in making up unshrunk cloth can result in a distortion of properly shrunk cloth, and that the cure usually lies in correcting the methods of the operatives, rather than in blaming the shrinker.

Co-operation by Laundries

Mr. Young explained how the laundries had been regularly used as a practical check on the efficiency of "RIGMEL" shrinking process, and remarked that where laundries obtained an apparent shrinkage additional to Rigmel it was often traced to very quick drying, which seemed "to have the effect of setting into the cloth a temporary contraction, which is not there if the fabric is given a chance to re-adjust itself more gradually from the wet state."

Referring to an implication that cloth was sometimes "overshrunk" by the finisher, resulting in extension of the cloth when laundered, Mr. Young pointed out that this accusation could be justified only if three things were examined:—

(1) The actual size of the neckband of the shirt when received by the laundry (as opposed to the marked size).

(2) The size in the wet state during laundering, but *before* drying or pressing or ironing.

(3) The final size for comparison with (1) and (2).

It was wrong to blame anyone until these three points had been investigated, in order to decide whether maker-up, launderer, or finisher was at fault.

Immunity from shrinkage required the co-operation of the maker-up and the laundry trade.

In summing up, Mr. Young said that there were many other aspects of the shrinkage question, for example, retail co-operation, the individual problems of different fabrics, the behaviour of sewing cotton, the meaning and correct use of "tolerances."

In regard to tolerances he had time only to remark that tolerances had no meaning except in relation to the particular wash-test used. An apparently lower tolerance may only mean that an inferior wash-test procedure is used as a basis. It is invidious for anyone to use general tolerances to compare one finisher's result with another, although this dubious comparison is not unknown.

It was important that standard testing methods should be established as soon as possible by the Textile Institute, as "once official testing procedure is evolved, finishers, merchants, makers-up and launderers will be able to discuss their problems on a common footing. Meantime, an increase of over four millions in the number of garments made from 'RIGMEL' shrunk cloth during 1939 is strong evidence that Rigmel is having a major effect in reducing the prevalence of shrinkage trouble for everybody concerned."

General Items

THE INSTITUTE LIBRARY

It has been suggested recently by members that more publicity should be given to the service that the Institute can (and does) render to members through its Library, for it is felt that many members are not familiar with this part of the Institute's work, and therefore do not use the Library as they might.

The Library Catalogue contains lists of the works, which, with a few exceptions, may be borrowed by members. Three books may be borrowed at once, and unless there is an urgent call from other members, they may be retained for 14 days. The Institute asks to be re-imbursed for the outward postage, and is thus in line with the great majority of libraries which send out books by post.

Space at the Institute for the storage of back numbers of journals is very strictly limited, and arrangements have therefore been made that certain journals shall be kept by the Research Associations to which they are sent for abstracting. These are still available to members on whose behalf they are borrowed from the Research Associations.

It should be pointed out that in general the journals from enemy countries have not been received since the outbreak of war. In the majority of cases these journals are sent in exchange for the *Journal of the Textile Institute*, and it is naturally hoped that the files will be completed when hostilities cease.

Practically all the better known English, American, French and German journals are filed at the Institute. Among those less frequently consulted the following are sent to the Research Associations for filing:—

Barbados: Department of Agriculture: Annual Report.
Bengal: Department of Agriculture Reports.
Boletin Mensual de Estadistica Agropecuaria.
Bollettino Della Associazione Italiana Di Chimica Tessili e Coloristi.
Bollettino Della Cotoniera.
Bombay: Annual Reports, Department of Agriculture.
Building Science Abstracts.
Bulletin of the Australian Mercantile Land Company.
Bulletin: British Non-Ferrous Metals Research Association.
Bulletin of the National Sheep Breeders Association.
Bulletin de la Société Industrielle de Rouen.
Bureau Voor Den Industrieelen Eigendom. Patents Journal and Trade Marks Journal.
Farm Reports.
Cataluna Textil.
Chimie et Industrie.
Cotton Oil Press.
Current Titles from Engineering Journals.
Cyprus: Department of Agriculture: Annual Report.
Bastfasern: Deutsche Forschungsinstitut fur.
Fuel Research Intelligence Station.
Georgia Experiment Station: Department of Agriculture.
Giornale di Chimica Industriale ed Applicata.
Imperial Bureau of Animal Genetics.
Imperial Bureau of Plant Genetics.
India Rubber Journal.
Industria (Boletin de la Sociedad de Fomento Fabril).
Institute of the Rubber Industry: Transactions.
Iowa State College: Journal of Science.
Jamaica Department of Agriculture: Annual Reports.
Franklin Institute Journal.
Journal of the Society of Textile Industry Japan.
La Maglieria.
New Zealand: Annual Sheep Returns.
Nyasaland: Department of Agriculture Reports.
Patent Journal (U.S.A.).
Physikalische Zeitschrift Die Sowjet Union.
Rayon World.
Spinner und Weber.
Sudan Department of Agriculture: Annual Reports.
Teintex.
Textile Review.
Textilia.
Tinctoria.
Uganda Department of Agriculture Reports.
Water Pollution Research Board Publications.

Obituary—Mr. Thomas Halstead

We have to record with regret the passing of Mr. Thomas Halstead, who has been a member of the Textile Institute since 1917. In Yorkshire his passing will be keenly regretted because of the long and valued service he rendered to the industry.

Mr. Halstead entered the firm of Messrs. Reuben Gaunt, Farsley, as an office boy and ultimately became a director of the firm. For over 30 years he was a member of the Bradford Textile Society, being at one time Chairman, and for the last two years its Honorary Treasurer. He had a wide circle of friends who appreciated his independent thought, his ready speech and his high moral attitude. He was a familiar figure at meetings of the Yorkshire Section of the Textile Institute and the Bradford Textile Society and he contributed frequently to the discussions which followed papers read to these bodies. He firmly believed that in disseminating knowledge and encouraging co-operation between various sections of the industry that the societies were doing work of great value. Research Associations and Technical Colleges enjoyed his strong support and amongst his other activities he had a keen interest in welfare work.

The TEXTILE INSTITUTE and The ROYAL SOCIETY OF ARTS

For some considerable time the Textile Institute and the Royal Society of Arts have had under consideration a scheme for co-operation regarding scholarships for students of Textile design. The first definite step has now been taken and has resulted in the virtual linking up of the Textile Institute Competitions with the Royal Society of Arts Bursaries Scheme. For the first time successful candidates in the Textile Institute Competitions will be eligible for the Royal Society of Arts bursaries, and members of the Institute and students taking part in the Competitions will therefore be interested in the following notice issued by the Royal Society of Arts.

Two Scholarships for Students of Textile Design

The Royal Society of Arts has just issued particulars of its Industrial Art Bursaries Competition for 1940.

Foreign travel being impracticable under present circumstances, the offer of Travelling Studentships has been temporarily suspended, but two Scholarships, to provide for more advanced study in this country, are offered, one each in the Furnishing Textiles and Dress Textiles industries respectively. The Scholarships are each of a value not exceeding £100.

The Competition is open to *bona fide* art students between the ages of 16 and 21, and to successful candidates in the Crompton Prize Scheme of the Textile Institute. The closing date for entries is May 21st.

The Competition, which was inaugurated two years ago, has the approval of the Board of Education, the Council for Art and Industry, the Federation of British Industries and the Design and Industries Association, and all of these bodies are represented on the Society's Industrial Art Bursaries Board which has been set up to administer the Competition.

Full particulars and conditions of entry may be obtained from the Secretary, Royal Society of Arts, c/o Basil Ionides, Esq., Buxted Park, Sussex.

Elections to Associateship and Fellowship have been completed as follows since the appearance of the previous list (March issue of the *Journal*):—

FELLOWSHIPS

CHAUNCEY EUGENE COKE
WALTER GARNER
PERCY HERBERT GEE
WALTER CROWTHER

ASSOCIATESHIP

RICHARD WARBURTON

24 JUL 1940
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THE JOURNAL OF THE
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PROCEEDINGS

NOTES AND ANNOUNCEMENTS

ANNUAL GENERAL MEETING, 1940

The Annual General Meeting was held at the Institute's headquarters in Manchester on Wednesday, 24th April, 1940. The retiring president, Mr. E. W. Goodale, occupied the chair, and he was supported by the Chairman of Council, Mr. W. Kershaw, the Acting Secretary, Mr. Frank Nasmith, the Hon. Treasurer, Mr. W. W. L. Lishman and a Past President, Mr. J. Crompton.

Mr. Goodale gave a short account of the activities during the previous year, and stressed the importance of work undertaken by the Institute in the war effort. The report was unanimously accepted. The auditors' report was then read to the meeting and the accounts were adopted.

Mr. H. Jaques, of Bradford, who was nominated by Council, was unanimously elected President for the ensuing year. Mr. Jaques then took the chair. He expressed his appreciation of the honour bestowed upon him and continued with his Presidential Address. He also thanked Mr. Goodale for the excellent service which he had rendered during his year of office. The retiring president replied, and took the opportunity of supporting Mr. Jaques' thanks to Mr. F. Nasmith who had done so much for the Institute especially since taking over the position of Acting Secretary.

Mr. T. C. Petrie (London), Mr. W. R. Wadsworth (Macclesfield), and Dr. E. Wildt (Leicester) were then elected vice-presidents, and Dr. Wildt thanked the meeting on behalf of those elected to this position.

The result of the ballot for election to membership of Council was given and the following were declared elected for a period of three years:—

H. C. Barnes
F. Chadwick
W. Davis
H. Greenwood
W. Howarth
W. E. King
H. Nisbet
W. Pritchard
A. W. Stevenson
W. Wilkinson

Messrs. Arthur E. Piggott, Son & Co., incorporated accountants, were unanimously re-elected as auditors.

THE PRESIDENTIAL ADDRESS

Mr. Jaques said:—

Ladies and Gentlemen,

I thank you very sincerely for the great honour you have to-day conferred upon me. I fully appreciate, and am grateful for, the confidence you have shewn in electing me to this high office and I shall do my utmost as your President to maintain the dignity of the position and to justify your confidence in me.

It is my first and very pleasant duty as your new President to tender our grateful thanks to Mr. Goodale, who, as our President, has rendered great service to the Institute during his term of office. I fully recognise that I am following some of the most capable and efficient men that I have ever met. During his period of office Mr. Goodale has worthily upheld the traditions established by the eminent Presidents who preceded him, who, by their unstinted service added progressively to the importance and standing of the Institute. I therefore thank Mr. Goodale on behalf of all our members for the excellent services he has rendered to the Institute and express the hope that we may long have the benefit of his advice.

There are two other past presidents of the Institute whom I would like to mention, and thank. I refer to Mr. John Emsley to whom I owe my textile training, and Mr. Nasmith, who was a tower of strength to me when I was your Chairman of Council and who guided and helped me so much as Chairman of the Finance and General Purposes Committee. We are fortunate in the Institute in having a man of the calibre of Mr. Nasmith as our Honorary Secretary.

I think I ought also to make reference to our indebtedness to Mr. Nasmith for his long and splendid service as Honorary Secretary in supervising the various activities of the Institute especially through the difficult times experienced since the outbreak of war. As most of you are aware our General Secretary, Mr. Robinson, at the request of Lord Woolton, has been lent to the Ministry of Supply, but the secretarial work has been efficiently continued by Mr. Ibbetson, our Assistant Secretary, and by Mr. Hall, our *Journal* Editor. The work of the Institute has been maintained at the usual high standard and your Finance and General Purposes Committee has never been better informed with regard to the finances of the Institute than it is to-day.

Apart from the personal call on Mr. Robinson, there have been other requests from the Ministry of Supply for assistance and these have been readily met. The Institute was mainly responsible for clearing up some difficulties the Ministry had with regard to webbing equipment and this was in no small measure due to the energy of Mr. Nasmith in bringing together the various parties interested in the component parts of webbing.

We are living in difficult times and the whole of the textile industry is faced with serious problems. The supreme thing before us and the whole nation, however, is the united effort to bring this terrible war to a victorious termination. Everything else has to be subordinated to that vital purpose. I am afraid that no reliable estimate can be made as to the period of the struggle, but the present position of affairs suggests that it will be a long one and we all recognise that it is our primary duty to spare no effort within our power to achieve the desired end.

War conditions have been responsible for various schemes of state control of industry. The various sections of the textile industry are affected in different ways. Coming from Yorkshire I am of course more familiar with the control of the wool textile industry than with the other sections. Being citizens of a country in which individual freedom is a precious heritage we do not take kindly to any form of state control, but we have had to recognise with a good grace the necessities of the situation. In the worsted section we had many difficulties to face at the outset owing to uncertainty about raw material supplies and prices. Manufacturers were handicapped in dealing with export trade because they were swamped with particulars from home trade customers against contracts which had remained in abeyance for very many months whilst there was additional difficulty due to the commandeering of crossbred wools for Government Service requirements.

In order to deal with some of these problems delegations from the trade have met the Wool Controller, who has welcomed constructive suggestions, and many, particularly with regard to the export trade, have been adopted. A price basis for raw materials has been fixed which will operate to the end of October, so far as export trade in fully manufactured goods is concerned, and valuable assurances have been given with regard to supplies of raw material to enable contracts to be fulfilled. As a special encouragement to exporters to obtain oversea business a bonus of 25 per cent. in subsequent wool allocations was offered on the basis of fabrics exported by the end of April and a further advantage has been given to exporters in the form of priority certificates which enable the manufacturer to obtain priority of supply of yarns for export orders.

Some firms were hampered during the severe wintry weather by a shortage of coal, but I think that has now been rectified. Another problem is the shortage of trained workers, due partly to the depressed state of trade prior to the war and partly to the calling up of men for the various fighting services. This has been modified to some extent by bringing in operatives from depressed areas to be trained for the textile trade.

Notwithstanding the difficulties I have mentioned and many I have not, the worsted industry is carrying on in what may be regarded as a satisfactory manner. I do not find any feeling of depression; on the other hand there seems to be an atmosphere of comparative cheerfulness and complacency. Everybody seems determined to make the best of things and to do their utmost in every possible way to keep things going. We should, however, guard against any tendency toward being too complacent or over-confident.

It is vitally necessary that in every phase of industry anything that could be regarded as waste or extravagance should be avoided. Nowadays money comes round much more quickly than it does in times of peace and the liquid position is such that it may create a false sense of prosperity. The extent of current liquid resources may prompt expenditure in various forms which would not really be justified on a long view. Future liabilities with regard to taxation in one form or another to pay for the war may be expected to be progressively heavy and the prudent industrialist will conserve rather than fritter away his resources.

I often wonder whether firms in the textile industry give the attention to scientific costing that the subject deserves. There is, I am afraid, a good deal of rough-and-ready rule-of-thumb method of working out costings. The Ministry of Supply has shown its appreciation of the importance of the question by employing experts in costings in connection with Government contracts. If firms would make greater use of expert accountants in working out and simplifying their costing systems they would save a great deal of time which is now wasted and would gain a much clearer idea of the true relationship between costs of production and selling prices. The handling of statistics and the analysing of costs of production is a matter that calls for the specialist and the trade would do well to make use of the best brains available for this purpose. Just as it is important that we should avoid waste of effort, mental and physical, as well as in material resources, so it is important that there should be no unnecessary overlapping by kindred technological societies who are all working toward the same goal. The agreement which has been reached between the Textile Institute and the British Standards Institution and the formation of the Textile Divisional Council, is a striking example of what can be achieved by collaboration and co-ordination when a problem is tackled by all parties concerned in the right spirit. The British Standards Institution is called upon by the Government to prepare and to issue Standard Specifications. According to our agreement with the B.S.I. all specifications relating to textiles are submitted to the Institute Standardisation Scheme before being issued as tentative standards. Some time ago there were meetings in connection with A.R.P. requirements to determine the obscuration value of materials for curtains and blinds.

This to my mind points the way to further progress along the lines of collaboration or by a definite linking up with the Textile Institute of societies which are doing valuable work in pure research or in the application of laboratory results to industrial practice. We have our Charter, and all that it stands for in prestige and authority, and we are willing to give the benefit of that Charter to other kindred associations or societies who might feel disposed to take advantage of it. Is it not desirable in the national interest, and in the interest of the textile industries, that all scientific and technological organisations definitely associated with textiles, should come under the wing, so to speak, of what might be termed the parent body? I do hope that these observations will be accepted in certain quarters in the spirit in which they have been made.

We are fully recognised by the Government as an organisation in which the best possible technical advice can be obtained from fully qualified experts in every branch of the textile industries, and at the request of Lord Woolton we have formed an Advisory Committee to which the Ministry of Supply can refer when advice is needed.

At this time our thoughts are naturally concentrated largely on the supreme task of winning the war. It is of course a vital necessity that the whole nation should combine in all spheres and strain every nerve and make every possible effort to achieve the desired end and finally to abolish Hitlerism and all that it stands for. But there is another task of almost equal importance and that is our preparation for winning the peace. We are a textile organisation and our interests and responsibilities are centred in the various sections of the textile industries. Is it not our duty in the national interest to see to it that during the period of the war we should leave no stone unturned to put the textile industries in the best possible position to win the peace in the realm of industry and commerce?

There will be vast problems to face in connection with the post-war reconstruction. Most of us are old enough to remember what happened after the last great war. We do not want to see repeated the mistakes and misjudgments which brought disaster to many great industrial concerns. When the war is over there will be keen and intensive competition by the leading industrial nations to re-capture lost markets and success will go to those who are best equipped for the race.

It is therefore imperative that organisations like the Textile Institute, instead of letting things slide because of the war, should do just the opposite. It is up to us to keep every branch of our work in the highest possible state of efficiency and readiness to tackle any problem which may arise. In days gone by the slogan of the armed forces used to be " Keep your armour bright and your powder dry ". To use less militant language it is our duty to see that no effort is spared to give the industries we have the honour to serve the highest possible benefit that can be obtained from a close and continuous study of all technical questions which make for efficiency and progress.

It is my desire as your President to see the Institute maintained during the war in a spirit of alertness and enterprise, always having in mind the tasks that will have to be faced after the war and it will be my earnest endeavour to lead you along those lines. From my experience of the quality and enthusiasm of the men who have so well served the Institute in the past, I know I can count on your loyal support. We are, so to speak, the trustees of a great work and we shall not be false to our trust.

PIN SETTING IN NOBLE COMBING

By S. Kershaw, F.T.I.

Head of the Textile Department, Technical College, Halifax.

There appears to be no recognised system of varying comb pinning according to the different qualities of wool being processed. The tables that are published in text-books may represent how comb circles are being pinned for the trade, but there is apparently no standard, all the text-books presenting different sets of figures regarding pin densities and sizes. When these tables are examined they reveal some general tendencies, but there are so many differences between them and so many apparent imperfections or inaccuracies, that it may be questioned whether circles pinned according to some of these particulars have ever been used. The accommodation for the fibres in the circles is not regular and the graduation in pins from few to many is not evenly progressive. Of these faults, if they are faults, more will be written later.

On the other hand these comb circles are claimed to be workable and many accept that as final proof regarding their suitability. There is no volume of complaint from woolcombers regarding the circles in use. This complacency may stamp those who suggest changes as interferers. But the great cost of drawing-off leathers and of dabbing brush repairs is well known, and when combers appreciate the relationship between comb pinning and the wearing out of these parts, the subject of comb pinning will be accepted as one ripe for discussion. These relationships exist. The drawing-off leathers have more work to do and encounter more resistance to drawing-off as the density of setting of the comb pins increases, and as a result they wear out more quickly. The dabbing brushes need more frequent repairs when dabbing wool between pins closely set than between those set at wider intervals. If, on the other hand, the pins are set too openly, neps and small pieces of vegetable matter appear in the combed wool. Indicative of the wide differences found in the pinning of comb circles the aggregate space between pins in one linear inch varies, in the published tables, from 0·18 inch to 0·64 inch.

In wool combing a field of pins receives prepared wool. The pins are upright, firmly embedded in their foundations, straight stemmed, tapering near the top, with sound points at their tips to withstand the wear of dabbing and fibre insertion. The fibres are dabbed into the pins from above and after this operation the fibre ends are gripped from outside the field of pins and are side drawn from them. This is the basic principle of Noble combing. The same principle is also used for partial combing in both the Lister and the square motion combs. While this principle, thus enunciated, is simple, the amount of detail involved in pinning, dabbing, and speeding is very great. In the study of all these things it may be forgotten that combing is fibre separation by means of steel pins which may be regarded as stationary while the fibres move, the fibres being pressed into the comb pins from above by brushes and removed from the side by revolving rollers.

Comb pins are tapered and the taper should begin about ⅜ths inch from the top of pin. Pins with longer taper allow more room for fibres, but the combing is not so clean, and vegetable matter which they should hold back, is allowed to go into the top. One benefit that may accrue from the use of tapered pins is that the dabbing brushes should wear longer. However, the disadvantages accompanying the use of tapered pins are greater than the advantages.

The pinning of comb circles has not received the attention due to so important a subject. While combers deplore the cost of dabbing brush repairs and drawing-off leather renewals, they contentedly continue to use circles which contribute much to the wearing out of these parts.

In a perfect comb circle the following conditions should obtain: (*a*) The density of pinning and strength of pin should be related to the quality of wool to be combed in them. (*b*) The pinning should be graduated progressively so that the fibres are treated first with few pins to avoid breakage and preserve fibre length and then with many pins to ensure thorough combing. (*c*) The aggregate space between the pins should be in proportion to the amount of wool placed in the pins at that point. The back rows of the large circle may have to take more wool than the front rows and the back rows of the small circle may have to take less wool than the front rows. (*d*) The spaces between adjacent pins should vary with (i) the number of pins per inch and (ii) the thickness of the pins. The aggregate space in one inch of comb circle is given by unity minus the product of the number of pins per inch and the pin diameter, and the space between two adjacent pins is found by dividing the aggregate space per inch of comb circle by the number of pins per inch.

The space between contiguous pins should be least on the inner row of the large circle and on the outer row of the small circles, and each succeeding row from the two mentioned should, by reason of the reduced number of spaces per inch per row, have increased distances between contiguous pins per row. In this way progressive combing is obtained.

Pins for combing are made in accordance with the British Standard Wire Gauge which is shown in the following table:—

Table I.

S.W.G. of Pins	Diameter of Pin. Inches	S.W.G. of Pins	Diameter of Pin. Inches
10	0·1280	21	0·0320
11	0·1160	22	0·0280
12	0·1040	23	0·0240
13	0·0920	24	0·0220
14	0·0800	25	0·0200
15	0·0720	26	0·0180
16	0·0640	27	0·0164
17	0·0560	28	0·0148
18	0·0480	29	0·0136
19	0·0400	30	0·0124
20	0·0360	31	0·0116

From the gauge number and the number of pins per inch the aggregate space and the space between contiguous pins can be calculated. An examination of comb circles in use shows that the aggregate space per inch varies from 0·180 to 0·640 inch. Table II. shows the aggregate space in one inch and the space between contiguous pins within the following limits of 5 to 50 pins per inch, 12 to 30 S.W.G. pin sizes and 0·280 to 0·520 inch aggregate space per inch.

By the use of this table combers and comb makers can readily acquaint themselves with many necessary details in comb circle pinning when using standard pins. Tables III. to VI. which give the suggested pinning of circles for different wool qualities have been derived from Table II.

It is claimed that circles made according to these particulars will give good combing, less wear on dabbing brushes, and longer life to drawing-off roller leathers. In these tables Column 2 shows the gradual increase of pin density in the direction of combing. Column 3 exhibits the gradually increasing fineness of the pins permitting increased density. In the most densely pinned rows flat pins are used, the width of these pins in the direction of the drawing-off pull giving stiffness where it is most needed. The aggregate space per inch on the large circles gradually increases towards the outside rows to accommodate the increased number of fibres between the pins in that area. There is also a steady increase in the aggregate space in each row, which is an improvement on the spasmodic increases of existing circles.

The space per inch in the various rows of the small circles is more regular. The fibres thin out towards the inner rows of pins, and were fibre accommodation the only consideration, less space per inch might reasonably be allowed in these rows. However the true nature of progressive combing must also be considered, hence the slight increase in aggregate space per inch allowed on the inside rows of the small circles. The regular amount of space per inch in all rows should result in reduced wear on dabbing brushes and roller leathers. It will also be noticed that there is a measure of true progression shown in Column 5, which records the spaces between contiguous pins in each row. The fibres pass through these rows in order and the wider spaces of the back row prepare the fibres for the more exacting fibre separation of the front and finer rows. This follows the principle of combing and fibres are more parallelised. At the same time, there is less tugging and fewer fibres are broken.

It is claimed by certain combers in the United States that our established system of pinning Noble comb circles is wrong, and that beyond the two finest rows of pins, much less densely set pins will effectively comb the wool. If this is true, then this method of pinning ought to be adopted at once, as it would (*a*) be less costly in pinning and upkeep, and (*b*) extend the usefulness of brushes and leathers. One firm in the United States is using the following pinning for fine wool and expresses satisfaction with the result shown in Table XII.

All combers agree that the front rows of pins should be as fine and close as possible in both circles to keep back neps and bits at the drawing-off. If, however, the pins in the front row are displaced, then a fine second row would act as a second line of defence, although it is unlikely that complete cover would be given. However, the comb figures quoted make it appear that in an ordinary set of botany circles as used in this country there are about 35,000 too many pins.

It is a well known fact in combing that the greater the number of the rows of pins, the more tightly the wool is held. More rows keep the fibres straighter and prevent locking of the fibres round the pins. This means that with fewer rows, the small circle of the five-row circle will be taking off more than an eight-rowed circle. At the drawing-off a circle with more rows will pass the wool through much more nearly parallelized.

Only a few of the numerous woolcombers appear to be pin-enlightened. Many can judge between the merits of different circles, but are unable to point out how improvements may be effected by increasing combing efficiency or reducing cost. When Mazzetti introduced the setting of flat pins in oblique order, i.e., not conforming to the radial lines of the circles, a new note was struck, interest in comb pinning was stimulated and many profited from the study, although the system was quickly abandoned, because increased wear was found to take place on the drawing-off leathers.

In view of the statement often made by woolcombers that it is the spaces and not the pins which count most in combing (although actually they cannot be dissociated) it is surprising that some effort has not been made to regularise pin spaces. When combers began to use the British Standard Wire Gauges for the sizes of pins they committed themselves to make the process fit the pins. One advantage of the S.W.G. is that there are numerous sizes. It is only when the study of pinning is undertaken in real earnest that the weakness of the S.W.G. for comb pins is discovered. This is what occurs in using it. Having decided upon a specific density for a particular row of pins, it is necessary to find a pin size which will leave a definite amount of aggregate space per inch. This is more nearly accomplished with fine pins than with coarse pins, but it is not easy, and the variations in the aggregate space per inch columns of Tables III to VI are indicative of the difficulty.

Table II. Showing Relationship between Pins per Inch, Size of Pins, Space in 1 inch of Pinning, and Space between Contiguous Pins, on Noble, Lister and Square Motion Combs.

Pins per inch.	S.W.G.	Space in 1 inch.	Space between Contiguous Pins.
5	12	0·480	0·0960
	13	0·540	0·1080
6	12	0·376	0·0627
	13	0·448	0·0746
	14	0·520	0·0867
7	12	0·272	0·0389
	13	0·356	0·0508
	14	0·440	0·0629
	15	0·496	0·0709
	16	0·552	0·0789
8	13	0·264	0·0330
	14	0·360	0·0450
	15	0·424	0·0530
	16	0·488	0·0610
9	14	0·280	0·0311
	15	0·352	0·0389
	16	0·424	0·0471
	17	0·496	0·0551
10	15	0·280	0·0280
	16	0·360	0·0360
	17	0·440	0·0440
	18	0·520	0·0520
11	16	0·296	0·0269
	17	0·384	0·0349
	18	0·472	0·0429
12	17	0·328	0·0273
	18	0·424	0·0353
	19	0·520	0·0433
13	17	0·272	0·0212
	18	0·376	0·0289
	19	0·480	0·0369
	20	0·532	0·0409
14	18	0·328	0·0234
	19	0·440	0·0314
	20	0·496	0·0354
15	18	0·280	0·0187
	19	0·400	0·0267
	20	0·460	0·0307
	21	0·520	0·0347
16	19	0·360	0·0225
	20	0·424	0·0265
	21	0·488	0·0305
17	19	0·320	0·0188
	20	0·388	0·0228
	21	0·456	0·0268
	22	0·524	0·0308
18	19	0·280	0·0156
	20	0·352	0·0195
	21	0·424	0·0236
	22	0·496	0·0276
19	20	0·316	0·0166
	21	0·392	0·0206
	22	0·468	0·0246
20	20	0·280	0·0140
	21	0·360	0·0180
	22	0·440	0·0220
	23	0·520	0·0260
21	21	0·328	0·0156
	22	0·412	0·0196
	23	0·496	0·0236
22	21	0·296	0·0134
	22	0·384	0·0174
	23	0·472	0·0214
	24	0·516	0·0234
23	21	0·264	0·0116
	22	0·356	0·0156
	23	0·448	0·0196
	24	0·494	0·0216
24	22	0·328	0·0136
	23	0·424	0·0177
	24	0·472	0·0197
	25	0·520	0·0217
25	22	0·300	0·0120
	23	0·400	0·0160
	24	0·450	0·0180
	25	0·500	0·0200
26	22	0·272	0·0105
	23	0·376	0·0145
	24	0·428	0·0165
	25	0·480	0·0185
27	23	0·352	0·0130
	24	0·406	0·0150
	25	0·460	0·0170
	26	0·514	0·0190

Table II :—*continued.*

Pins per inch.	S.W.G.	Space in 1 inch.	Space between Contiguous Pins.
28	23	0·328	0·0117
	24	0·384	0·0137
	25	0·440	0·0157
	26	0·496	0·0177
	27	0·557	0·0204
29	23	0·304	0·0105
	24	0·362	0·0125
	25	0·420	0·0145
	26	0·478	0·0165
	27	0·524	0·0181
30	23	0·280	0·0093
	24	0·340	0·0113
	25	0·400	0·0133
	26	0·460	0·0153
	27	0·508	0·0169
31	24	0·318	0·0102
	25	0·380	0·0122
	26	0·442	0·0142
	27	0·492	0·0155
32	24	0·296	0·0092
	25	0·360	0·0112
	26	0·424	0·0132
	27	0·475	0·0148
	28	0·526	0·0164
33	24	0·274	0·0083
	25	0·340	0·0103
	26	0·406	0·0123
	27	0·459	0·0139
	28	0·512	0·0155
34	25	0·320	0·0094
	26	0·388	0·0114
	27	0·442	0·0130
	28	0·497	0·0146
35	25	0·300	0·0086
	26	0·370	0·0106
	27	0·426	0·0122
	28	0·482	0·0138
	29	0·524	0·0155
36	25	0·280	0·0078
	26	0·352	0·0098
	27	0·410	0·0114
	28	0·467	0·0130
	29	0·510	0·0147
37	26	0·334	0·0090
	27	0·393	0·0106
	28	0·452	0·0122
	29	0·497	0·0139
	30	0·541	0·0146
38	26	0·316	0·0083
	27	0·377	0·0099
	28	0·438	0·0115
	29	0·483	0·0133
	30	0·529	0·0139
39	26	0·298	0·0076
	27	0·360	0·0092
	28	0·423	0·0108
	29	0·470	0·0125
	30	0·516	0·0132
40	26	0·280	0·0070
	27	0·344	0·0086
	28	0·408	0·0102
	29	0·456	0·0119
	30	0·504	0·0126
41	26	0·262	0·0064
	27	0·328	0·0080
	28	0·394	0·0096
	29	0·442	0·0113
	30	0·492	0·0120
42	27	0·311	0·0074
	28	0·378	0·0090
	29	0·429	0·0107
	30	0·479	0·0114
43	27	0·295	0·0068
	28	0·364	0·0084
	29	0·415	0·0101
	30	0·467	0·0108
44	27	0·278	0·0063
	28	0·349	0·0079
	29	0·402	0·0096
	30	0·454	0·0103
45	27	0·262	0·0058
	28	0·334	0·0074
	29	0·388	0·0091
	30	0·442	0·0098
46	28	0·319	0·0069
	29	0·374	0·0085
	30	0·430	0·0094
47	28	0·304	0·0065
	29	0·361	0·0081
	30	0·417	0·0089
48	28	0·290	0·0060
	29	0·347	0·0076
	30	0·405	0·0084
49	28	0·275	0·0056
	29	0·334	0·0072
	30	0·392	0·0080
50	28	0·256	0·0052
	29	0·320	0·0068
	30	0·380	0·0076

To meet the need of having pins made to fit the process, 14 sizes are suggested for comb pinning, as shown in Table II. These sizes demand definite densities; for example, the pin 0·0139 in. diameter to be set 46 to the inch; the pin 0·0152 in. diameter to be set 42 to the inch; and so on. There are definite limits to pin densities in this scheme, but none that need cause alarm, for it is claimed that the circles made by their adoption will, by reason of the regular amount of aggregate space per inch, the fewer drills required for boring, and the fewer sizes of pins used, make better circles at smaller cost. The aggregate space per inch will be a fixed amount and at no part will there be expensive wear on brushes and drawing-off leathers due to tight places in the pins.

SUGGESTED PINNING OF NOBLE COMB CIRCLES FOR DIFFERENT QUALITIES OF WOOLS.

	Large Circle				Small Circle			
No. of row	Pins per inch	S.W.G.	Aggregate space per inch	Space between pins	Pins per inch	S.W.G.	Aggregate space per inch	Space between pins
Table III. Botany Circles.								
1	42	28	0·378	0·0090	46	29	0·374	0·0088
2	41	28	0·394	0·0096	43	28	0·364	0·0084
3	37	27	0·393	0·0106	38	27	0·377	0·0099
4	33	26	0·406	0·0123	34	26	0·388	0·0114
5	30	25	0·400	0·0133	31	25	0·380	0·0122
6	27	24	0·406	0·0150	28	24	0·384	0·0137
7	24	23	0·424	0·0177	25	23	0·400	0·0160
8	20	22	0·440	0·0220	21	22	0·412	0·0196
9	20	22	0·440	0·0220				
10	19	22	0·468	0·0246				
11	19	22	0·468	0·0246				
Table IV. For Fine Cross-bred Wools.								
1	32	25	0·360	0·0112	36	26	0·352	0·0098
2	31	25	0·380	0·0122	35	26	0·370	0·0106
3	28	24	0·384	0·0137	31	25	0·380	0·0122
4	25	23	0·400	0·0160	26	23	0·376	0·0145
5	21	22	0·412	0·0196	17	20	0·388	0·0228
6	18	21	0·424	0·0236	15	19	0·400	0·0267
7	18	21	0·424	0·0236				
8	14	19	0·440	0·0314				
9	14	19	0·440	0·0314				
10	11	18	0·472	0·0429				
Table V. For Medium Cross-bred Wools.								
1	29	24	0·362	0·0125	32	25	0·360	0·0112
2	28	24	0·384	0·0137	29	24	0·362	0·0125
3	25	23	0·400	0·0160	26	23	0·372	0·0145
4	21	22	0·412	0·0196	22	22	0·384	0·0174
5	18	21	0·424	0·0236	19	21	0·392	0·0206
6	16	20	0·424	0·0265	14	19	0·440	0·0314
7	14	19	0·440	0·0314				
8	14	19	0·440	0·0314				
9	10	17	0·440	0·0440				
10	8	16	0·488	0·0610				
Table VI. For Long Wools.								
1	22	22	0·384	0·0174	25	23	0·400	0·0160
2	21	22	0·412	0·0196	22	22	0·384	0·0174
3	18	21	0·424	0·0236	19	21	0·392	0·0206
4	16	20	0·424	0·0265	15	19	0·400	0·0267
5	12	18	0·424	0·0353	12	18	0·424	0·0353
6	10	17	0·440	0·0440				
7	8	16	0·488	0·0610				
8	8	16	0·488	0·0610				
9	7	15	0·496	0·0709				

SUGGESTED PINNING FOR NOBLE COMB CIRCLES FOR DIFFERENT QUALITIES OF WOOLS USING SPECIAL PIN SIZES.

(See Table XII).

	Large Circle				Small Circle			
No. of row	Pins per inch	Pin diam. in ins.	Aggregate space per inch	Space between pins	Pins per inch	Pin diam. in ins.	Aggregate space per inch	Space between pins
Table VII. For Botany								
1	42	0·0152	0·360	0·0086	46	0·0139	0·360	0·0078
2	38	0·0168	0·360	0·0095	42	0·0152	0·360	0·0086
3	38	0·0168	0·360	0·0095	42	0·0152	0·360	0·0086
4	34	0·0188	0·360	0·0106	38	0·0168	0·360	0·0095
5	30	0·0213	0·360	0·0120	30	0·0213	0·360	0·0120
6	26	0·0246	0·360	0·0128	26	0·0246	0·360	0·0128
7	26	0·0246	0·360	0·0128	22	0·0291	0·360	0·0164
8	22	0·0291	0·360	0·0164				
9	22	0·0291	0·360	0·0164				
10	18	0·0355	0·360	0·0200				
11	18	0·0355	0·360	0·0200				
Table VIII. For Fine Cross-bred Wools.								
1	34	0·0188	0·360	0·0106	38	0·0168	0·360	0·0095
2	30	0·0213	0·360	0·0120	34	0·0188	0·360	0·0106
3	30	0·0213	0·360	0·0120	30	0·0213	0·360	0·0120
4	26	0·0246	0·360	0·0128	22	0·0291	0·360	0·0164
5	22	0·0291	0·360	0·0164	18	0·0355	0·360	0·0200
6	18	0·0355	0·360	0·0200	14	0·0456	0·360	0·0257
7	18	0·0355	0·360	0·0200				
8	14	0·0456	0·360	0·0257				
9	14	0·0456	0·360	0·0257				
10	10	0·0640	0·360	0·0360				
Table IX. For Medium Cross-bred Wools.								
1	30	0·0213	0·360	0·0120	34	0·0188	0·360	0·0106
2	30	0·0213	0·360	0·0120	30	0·0213	0·360	0·0120
3	26	0·0246	0·360	0·0128	26	0·0246	0·360	0·0128
4	22	0·0291	0·360	0·0164	22	0·0291	0·360	0·0164
5	22	0·0291	0·360	0·0164	18	0·0355	0·360	0·0200
6	18	0·0355	0·360	0·0200	14	0·0456	0·360	0·0257
7	14	0·0456	0·360	0·0257				
8	10	0·0640	0·360	0·0360				
9	8	0·0800	0·360	0·0450				
10	6	0·1066	0·360	0·0600				
Table X. For Long Wools.								
1	22	0·0291	0·360	0·0164	26	0·0246	0·360	0·0128
2	22	0·0291	0·360	0·0164	22	0·0291	0·360	0·0164
3	18	0·0355	0·360	0·0200	18	0·0355	0·360	0·0200
4	14	0·0456	0·360	0·0257	14	0·0456	0·360	0·0257
5	14	0·0456	0·360	0·0257	10	0·0640	0·360	0·0360
6	10	0·0640	0·360	0·0360				
7	8	0·0800	0·360	0·0450				
8	6	0·1066	0·360	0·0600				
9	6	0·1066	0·360	0·0600				

Table XI. Suggested New Pin Sizes for Use in Wool Combing.

For Pin Density per inch	Diameter in inches
46	0·0139
42	0·0152
38	0·0168
34	0·0188
30	0·0213
26	0·0246
22	0·0291
18	0·0355
14	0·0456
10	0·0640
8	0·0800
6	0·1066

Table XII

	Large Circle				Small Circle			
No. of row	Pins per inch	Size of Pins S.W.G.	Aggregate space per inch	Space between pins	Pins per inch	Size of Pins S.W.G.	Aggregate space per inch	Space between pins
1	42	27	0·311	0·0074	46	28	0·319	0·0069
2 to 7 Large circle	12	17	0·328	0·0273				
2 to 5 Small circle					12	17	0·328	0·0273

SUMMARY

1. Attention is drawn to the differences between the various particulars given in text-books relating to the pinning of Noble comb circles, for the ultimate benefit of the combing industry in general, and for textile technology in particular. The figures referred to are copied out by students and others who rarely challenge their correctness, or consider the principles underlying wool combing.

2. It is suggested that an examination of pinning should be made by combers, especially by those bodies associated for watching the interests of wool combing and circle pinning.

3. New methods of pinning are set out, and these offer a challenge to existing methods and can be used as a basis for discussion.

Yorkshire Section

At the meeting on 14th March, 1940, which was held at the Midland Hotel, Bradford, Mr. J. Pike delivered a lecture entitled "Some Industrial Eyesight Problems". Mr. J. R. Emms occupied the Chair. His discourse covered a wide field, from the simple principles of optics to the correction by means of spectacles of eyesight defects. He dealt also with illumination and its important connection with efficiency.

Dr. W. T. Astbury, F.R.S.

Many members of the Institute will be interested in the recent election to the Fellowship of the Royal Society of Dr. W. T. Astbury, of the University of Leeds.

Dr. Astbury was educated at the Longton High School, Stoke-on-Trent, and Jesus College, Cambridge, where he held a science scholarship. After serving in the Army from 1917 to 1919 he was awarded a First Class Natural Science Tripos, Part I (Chemistry, Physics and Mineralogy) in 1920. In 1921 he obtained a First in Part II (Physics).

In 1921 he was appointed to a Demonstratorship in Physics at University College, London, and was assistant to Sir Wm. Bragg, F.R.S., in 1922-23. He then moved to the Davy Faraday Research Laboratory, where he was Sir Wm. Bragg's assistant until 1928, when he became Lecturer in Textile Physics and Director of the Textile Physics Research Laboratory of the University of Leeds. He was appointed to a Readership in 1937.

Dr. Astbury graduated M.A. (Cambridge) in 1931 and Sc.D. in 1937. He became a Fellow of the Institute of Physics in 1935, having served on the Board during the period 1933-37. He is a member of the General Committee of the British Association and of the Councils of the British Pottery and British Refractories Research Associations. Also he is a member of the Textile Institute, the Faraday Society and the Kolloid Gesellschaft.

Among other recognitions of his work are the award of the Medal of the University of Lille 1933, the Warner Medal of the Textile Institute in 1935 and the Actonian Prize of the Royal Institution of Great Britain 1935.

Dr. Astbury's pioneer work lies in the application of X-rays to the elucidation of the structure of textile fibres. His papers have appeared in the Philosophical Transactions of the Royal Society and his book "The Fundamentals of Fibre Structure" is well known.

Reviews

All About Wool: *Diccionario de Terminos Laneros,"* by Pablo Link, Buenos Aires, 1940.

This is a dictionary of wool terms with English and Spanish definitions on each page. Much useful information is given, but some of the definitions are misleading. Definitions of words used in a genetic sense, such as " strain " frequently employ the term " offspring " irrelevantly. Definitions of terms used specifically in wool science are sometimes inaccurate and inadequate, and in many instances this applies also to explanations of the better-known terms, such as for example " Cape Wool." The disease liver rot is confused with the organism causing the condition. Examples of these errors could be multiplied.

The book would be improved by careful revision, and it is hoped that this may be done in any further edition which may appear. In the meantime, it should prove useful to students of textile matters who wish to use the Spanish language.

A. B. Wildman.

First Procter Memorial Lecture.—The Molecular Structure of the Fibres of the Collagen Group. By W. T. Astbury, M.A., Sc.D., F.Inst.P. Published by the International Society of Leather Trades' Chemists, 17, Leathermarket St., London, S.E.1.

The First Procter Memorial Lecture does more than inaugurate another series of lectures it calls to mind the work of the man whose name is associated with it. Procter was a man who appreciated to the full the rightness of industry, realising that if it had not been right it could not have survived. More than any scientist he was aware that, long before the organisation of the knowledge we call Science, the tanner tanned, the dyer dyed, and the housewife laundered and even the humble wasp made paper ; he therefore set his face toward the explanation of the well-established industrial processes, knowing that it was from this kind of investigation that further progress could be made. Men of his type are all too rare, and the first lecture commemorating his work has been awaited by most of the leather and leather-using trades as well as by a wider public outside.

We do not by any means suggest that this reprint is not easily read because it is, in fact, a clear and concise statement to those who have followed the work of Dr. Astbury and others, but it must be difficult reading for many who have not been able to keep abreast of every development likely to be of interest to their industry. After all, the scientist in industry is a busy man and finds it extremely difficult to keep in touch with his own industrial literature. Consequently it is certain that the majority of Procter's old pupils would read and enjoy Dr. Astbury's lecture all the more if special scientific items could be eliminated or explained. One is grateful to Dr. Astbury for his handling of the subject and it is with pleasure that one reads such a phrase as " the beauty and perfection of protein structure."

That this lecture is of the " Procter " type is clear when one can see how it explains things which have been known in the leather industry from time immemorial. For example, the behaviour of collagen in hot water is exactly similar to that which is seen when chamois leather is tucked, or, i.e., when a washleather is put into hot water ; and the explanation given of how this behaviour may arise becomes immediately clear and a pleasure to read. H.S.

Kingzett's Chemical Encyclopaedia, Sixth Edition, revised and edited by Ralph K. Strong, Ph.D. Published by Baillière, Tindall, & Cox, 7 & 8, Henrietta Street, London, W.C.2. Price 45/-.

The Sixth Edition of this important work has been revised and edited by Ralph K. Strong, and the late Sir Gilbert T. Morgan contributed a foreword.

There are numerous important changes which have been made in order to bring the encyclopaedia up to date. These have been made without unduly increasing the size of the volume which may now be regarded as having reached the limit for a single book.

For the many who have to use chemistry without being chemists such a work is of the utmost value. It is authoritative and well supplied with references to many of the more important subjects. The revision has been thoroughly done and the value of the work is consequently increased.

The National Physical Laboratory Report for the Year 1939. Published by His Majesty's Stationery Office, London. Price 2s. 6d. net.

The National Physical Laboratory Report for the year 1939 indicates that the laboratory has fully maintained the high standard normally expected from such a fine institution. Though references appear to the temporary suspension of certain fundamental researches as the result of undertaking work for the Government in connection with the war, a nice balance seems to be held between test work and research proper.

Some parts of the Report employ extremely condensed statement, and a deep knowledge of the subject referred to is essential if one is to realize how much care and energy have gone into work which is dismissed in 6 or 7 lines. The Report provides interesting reading even for those whose knowledge of science is not extensive. It sets an example which might well be more closely copied by certain other organisations of a somewhat similar character.

General Items

Institute Membership

At the April meeting of Council, the following applicants were elected to Membership of the Institute:—

Ordinary.

A. N. Cooke, 144/150, Bradford Road, Dewsbury (Wool & Hair Merchant, A. N. Cooke & Co., Ltd.).

A. Evans, 33, Hurst Road, Hinckley, Leics. (Full Fashion Manager, H. Flude and Co., Hinckley).

P. E. Evans, "Torridon", Daylesford Road, Cheadle, Cheshire (Director, Norman Evans & Rais, Ltd.).

E. Weyl, 26, Parke Avenue, Benchill, Northenden (Managing Director).

Junior.

R. O. Beckett, 119, Frances Street, Newtownards, N. Ireland (Manager, Flax and Hemp Spinning Mill, George Walker & Co., Ltd.).

E. P. Ghadiali, 285, Frere Road, Ballard Estate, Fort Bombay, India (Weaving Assistant, Spring Mills, Dadar).

G. E. Key, 26, Ivy Grove, Ripley, Derby (Textile Chemist in Dyeing and Finishing Works).

S. Li, 208, Queensway, Rochdale (Student apprentice at Tweedales & Smalley (1920) Ltd., Castleton).

TEXTILE INSTITUTE DIPLOMAS

Elections to Fellowship and Associateship have been completed as follows, since the appearance of the previous list (April issue of the *Journal*).

FELLOWSHIP

JOHN ROBERT EMMS, A.T.I.
Worsted Combing and Spinning Manager, W. H. Foster Ltd., Denholme, Nr. Bradford.

WILLIAM ALEXANDER DICKIE, B.Sc. (Lond.), F.I.C., F.R.S.A.
Woven Fabric Manager, British Celanese Ltd., London.

ASSOCIATESHIP

ALAN FOSTER.
SADI ARAL.
ARTHUR MATTHEW BAILEY.

Addition to the Library

"**The Social Functions of Science**", by J. D. Bernal, F.R.S. (Presented by F. Scholefield, Esq.)

JUNE 1940

LIBRARY

THE JOURNAL OF THE TEXTILE INSTITUTE

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PROCEEDINGS

NOTES AND ANNOUNCEMENTS

Yorkshire Section

SOME DUTIES OF THE TECHNICAL MANAGEMENT IN WOOLLEN MANUFACTURE*

By LEONARD BELLWOOD, A.T.I.

Apart from being in control of a productive organisation the duties of the technical management of a woollen manufactory are very varied. There have been cases, particularly in public and semi-official bodies, of individuals without technical knowledge of the work being placed in control of such organisations, and the question naturally arises as to whether such a control could be successful in the textile trade. For the conduct of a successful woollen manufacturing business a knowledge of every process carried on by the management is necessary. A superficial knowledge does not help materially in the solution of many problems which arise.

Policy

One of the most important duties of the management is that of deciding the policy of the firm as regards the types of cloth to be produced. It is obvious that no single concern can produce every type of cloth and a decision must be made as to which types shall form the principal lines. It may be argued that the machinery installed is a deciding factor and this is partly correct since woollen machinery is adaptable to a wide range of types. This consideration is therefore of minor importance.

The main problem of policy is of greater significance to-day than hitherto for many technical managers. The reason is that many woollen manufacturers have accepted large contracts for the supply of cloths for uniform for the Services, which utilise probably half or even more of the available machinery. With the remaining machinery making goods for civilian wear, the highest possible output must be ensured. Demand for textile fabrics is at a high level to-day and customers of long standing in addition to those with newer accounts tend to be impatient. A comprehensive knowledge of markets and cloths is necessary to policy determination, as obviously the highest possible production must be obtained from the available machinery in order to retain connections which may have been built up in past years at no small cost in pattern making, careful thought and the perseverance of the salesman.

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* Condensed from a paper read to the Yorkshire Section on 22nd February, 1940.

Wool rationing has also created many problems which require far more than a layman's knowledge of textile materials and manufacturing processes in order that the best use is made of the amount of wool allowed. In woollen manufacturing many types of waste fibres are extensively employed. As these are not yet subject to control a knowledge of the types available and also the cloths in which it is not only possible but practicable to use them, is necessary. It is a common impression that the materials available dictate the type of fabric to be made, but this is not usually entirely true where technically trained men are in control and where the materials are purchased in accordance with the planned policy.

Another factor which deserves attention when the policy is being decided is that of the personnel. The numbers of skilled operatives available are falling as a result of the calls to the fighting forces and their places are being taken in many cases by trainees. Where skilled workmanship is required at every stage it may be advisable to reduce the quantity produced in order that quality may be maintained.

Objects of Management

Too many woollen manufacturing concerns are collections of independent sections which do not work together in harmony. The technical manager should teach the operatives in a section that their finished product is the raw material of the next, and that the more complete their task the better and smoother is the work of their fellows in the next process. Once the proper spirit is established between the various sections the technical manager has made a great step towards achieving the highest efficiency.

The detailed work of the technical management in the various processes in woollen manufacture will now be considered.

Wool Scouring

In this, the first process after the wool is sorted and graded, care must be taken to avoid damage. The main points to observe are the type of detergent used, the strengths of the solutions, the temperatures and the time factor. It is not sufficient merely to see that the bowls are recharged regularly, the method of replenishment must be carefully controlled, and the introduction of the fresh solution arranged so that no damage is done to the fibre.

Wool Drying

This process is also one in which the fibre may be irreparably damaged by careless handling and inefficient control. The temperature, weight of material moving per hour, and the rate of movement of the air current are points requiring attention.

Blending

This operation calls for a high degree of technical skill and also a wide knowledge. In the production of woollen yarns greater liberty in the choice and mixing of fibre types is permissible than in the case of worsted yarns. Experience is essential before the count and strength of the resultant yarn may be visualized from the constituents and composition of the blend. Blending to price is an important duty of the management.

Oiling

There are many factories in which the application of oil to a blend of fibres is a slipshod and uncontrolled process regarded as a necessary evil. If a blend of fibres is under oiled, various difficulties are experienced in carding and the succeeding processes. Oils should be examined for the estimation of the saponifiable fraction, acid content and for freedom from impurity.

Carding

This process in the conversion of fibres to yarn is very important. Careless and inefficient setting of the machine can result in much fibre breakage and poor spinning. Points worthy of the attention of the technical manager are the type of clothing upon each part, the speeds of the parts, and the relative counts of the condensed sliver and the yarn. Close inspection of the regularity of the mixing of the fibres in the condensed sliver repays one for the time occupied and a regular inspection is also recommended of the fibre length in the sliver. Fibre breakage is inevitable in carding but it can be kept down to the minimum. The fibre length of the carded material should be compared with that of the blend before carding. Valuable information may thus be obtained as it may be found that one particular type of fibre is relatively weak, a defect which may not have been apparent in the first inspection of the material.

Spinning

Usually the most important object in spinning is to produce yarn of the greatest strength compatible with the special characteristics of yarn of its type. Faulty setting of the spinning machinery is reflected in the quality of the yarn spun. Regular tests for count, twist, strength and levelness are essential. Where more than one type of spinning machine is used the potentialities of each should be fully realized, so that any blend may be spun on the most suitable machine.

Winding and Warping

These processes are regarded by many as of minor importance only and yet they can be the source of faults. Yarn tension and machine speeds are probably the most important factors to be observed. The larger the package the higher the efficiency in general.

Weaving

Where more than one type of loom is employed the technical manager should know of what each particular type is capable in order to ensure also that cloths are designed to be woven in each type. The cloth structure is a most important factor in weaving efficiency and freedom from stoppages. Each new pattern produced should be carefully observed during weaving in order that difficulty will not be encountered when bulk orders are woven. The speed of the loom has an important bearing upon production, but high speed may be attained by the sacrifice of quality. For automatic looms suitable fabrics should be chosen after the capabilities of the loom have been ascertained. Observation of the causes of stoppages in weaving is well repaid as valuable information is obtained regarding the yarns, cloth setting, and loom setting.

Mending

This is a process in which machinery has not yet been used, and it is difficult to see how it could be employed. Many managers consider that beyond general supervision there is little scope for technical control in a mending room. In certain woollen cloths, however, a heavily milled finish may render unnecessary the darning-in of single threads missing for short distances.

Finishing

In the scouring and milling processes attention must be given to the matters mentioned under wool scouring. The use of water in washing off after scouring and milling is a factor of great importance.

Tests

At various stages in the above discussion testing of the product has been advocated and this point cannot be too strongly stressed. Regular and constant testing enables faults to be discovered and rectified as early as possible. The results of tests should be recorded. In general graphical representation is advisable since it is possible to ascertain quickly and easily the value of one product in comparison with another.

Personnel

Since one of the primary objects of technical management is economical production, it is imperative that the vitally important human factor should receive adequate attention. The technical manager needs to be a psychologist. Frequently it is possible, after careful observation, to effect a transfer from one section to another with corresponding benefit both to the operative and the production. The aim of the technical management should be to build up a staff of highly efficient operatives in every department. A series of tests can be devised to demonstrate the suitability of the applicant for a particular position.

Although the conditions obtaining in our factories have improved considerably in recent years, many changes are necessary before we can regard conditions generally as satisfactory. Some managements regard costs incurred by the provision of modern conveniences as unnecessary but expense involved in a well conceived scheme designed to improve working conditions is really a good investment. Lighting and temperature of work rooms are two important considerations since they have a direct bearing not only upon the quality of the product but upon the temperament and health of the operative, the cost of the operations carried out and the accident rate.

Cleanliness too deserves attention. Modern factories need not be the dirty, dismal, evil smelling hovels which characterised the wool textile trade of the last century. The more nearly conditions approach the ideal the higher will be the efficiency.

Labour Saving

The technical management of a factory must be adaptable and ready to assimilate new ideas or it cannot continue to be successful. Considerable time is wasted and large expense is involved by an ill designed layout of plant. Duplicate journeys may be necessary, the material passing over the same ground several times and requiring effort for each journey. Use should be made of modern methods of conveying materials, and plant should be rearranged so that a continuous flow is obtained.

Costs

Many people claim that the costs section of a manufacturing concern should be a separate section. Costs are of paramount importance to the technical management and it is difficult to see how costing and technical management can be kept in separate water-tight compartments. The subject is too extensive for discussion in a few paragraphs.

If, as in the period following the Great War, there is a slump after the present hostilities, costing and efficiency will have to be far more closely studied than it has been in the past.

THE TEXTILE INSTITUTE

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Telephone BLACKFRIARS 2016, MANCHESTER

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At the meeting of Council on 22nd May, 1940, the honorary officers were re-elected and it was resolved that the personnel of Committees for the year 1940-1941 should be as in the lists below.

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D. Wilson	B. R. D. Sharp	F. Pickles

COMMITTEE ON EDUCATION AND RECRUITMENT OF TEXTILE OPERATIVES

At the Annual Meeting of the Lancashire Section of the Textile Teachers' Association on 18th April, 1940, Mr. J. Read contributed, as the opening of a discussion, a paper on " The Future of Technical Training and the Cotton Industry ". This paper was reproduced in the April issue of the *Journal* of the Textile Institute.

During the meeting a resolution was passed unanimously, asking the Institute, as an impartial body, to consider " . . . . . the recruitment of young people for the cotton industry, the provision of an educational ladder in technical matters with prospects of progress and promotion in the mills, and so ensure a sufficient supply of workers and leaders in the cotton trade ".

The attention of the Emergency Committee was drawn to the matter and Council decided to set up an Institute Committee to consider the Education and Recruitment of Textile Operatives in all branches of the Textile Industry. It was agreed that the Committee should be constituted as follows:—

Ex-officio	Chairman of Council	W. Kershaw
	Acting Secretary	F. Nasmith
	The Chairman of Scholarship Committee	G. H. Thompson
	The Chairman of Textile & Designs Committee	J. Crompton
	The Chairman of Diplomas Committee	J. E. Dalton
	The Chairman of National Certificates Committee	F. W. Barwick
	The Chairman of Editorial Board	H. Richardson

Two representatives from each Regional Section of the Institute (one teacher and one industrialist in each case).

Irish Section	S. A. G. Caldwell	F. J. W. Shannon
Lancashire Section	F. Chadwick	J. Read
Macclesfield, Leek & Congleton	Two nominations to be made.	
Midlands Section	S. E. Ward	J. Chamberlain
Scottish Section	W. Lockhart	A. W. Stevenson
Yorkshire Section	T. H. Robinson	S. Kershaw

Four representatives of Council (two teachers and two members not engaged in teaching).

H. G. Greg	W. Pritchard
H. Bromiley	W. Wilkinson

Three H.M. Inspectors as Assessors.

Lancashire Section

At a meeting of the Lancashire Section Committee called for the purpose of arranging the programme of lectures for the session 1940-1941, a suggestion was made that one meeting should be devoted to short papers by members of the Section. It was urged that some members who, in the present busy times, would be unable to devote the necessary time to a larger effort, could deal briefly with some interesting subject. The Hon. Secretary, Mr. H. P. Curtis, will be pleased to receive offers to contribute such short papers. These should be sent in as early as possible.

General Items

Institute Membership

At the May and June meetings of Council, the following applicants were elected to membership of the Institute:—

Ordinary.

C. C. Gordon, Albany Felt Co., Albany, N.Y., U.S.A. (Chemist).

A. K. Iyengar, 42, Garden Reach, Calcutta (Weaving Master, Kesoram Mills Ltd.).

K. Wassef, College of Technology, Sackville Street, Manchester (Student).

W. C. Woods, "Mount View", Ffordisa, Prestatyn, N. Wales (In charge Physical Testing Laboratory, Messrs. Courtaulds Ltd.).

Junior.

Miss I. L. Carr, 83, Arran Road, Catford, London, S.E.6 (Assistant at Air Ministry Textile Laboratory).

J. F. Master, 124, Holbrook Lane, Foleshill, Coventry (Laboratory Assistant, Messrs. Courtaulds Ltd., Coventry).

TEXTILE INSTITUTE DIPLOMAS

Elections to Fellowship and Associateship have been completed as follows since the appearance of the previous list (May issue of this *Journal*):—

FELLOWSHIP

FRANK BRAYSHAW,
Technical Representative, F. W. Berk & Co. Ltd., London.

MATTHEW MICHAEL TAYLOR, A.T.I.,
Technical Investigator, British Celanese Ltd., Spondon.

CHARLES DODGSON WALTON, A.M.I.Chem.E., F.C.S., F.R.S.A.,
General Works Manager, Celanese Corporation of America, Cumberland, Maryland, U.S.A.

ASSOCIATESHIP

MAN CHEUK LUI.
JOHN PITT MOFFAT.

NOTICES: INSTITUTE MEETINGS

Tuesday	2nd July	*Manchester*—1.15 p.m. Meeting of the Publications Committee at the Institute.
Tuesday	2nd July	*Manchester*—2.45 p.m. Meeting of the Diplomas Committee at the Institute.
Thursday	4th July	*Manchester*—11.15 a.m. Meeting of the Development and Bye-Laws Sub-Committee, at the Institute.
Wednesday	24th July	*Manchester*—11.30 a.m. Meeting of the Finance and General Purposes Committee at the Institute.
Wednesday	24th July	*Manchester*—2.45 p.m. Meeting of the Council at the Institute.
Thursday	25th July	*Manchester*—12 noon. Meeting of the Joint Committee re National Certificates in Textiles at the Institute.

Meetings of the Textiles and Designs Committee and Adjudicating Sub-Committees are to be arranged.

4. NOV. 1940
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THE JOURNAL OF THE
TEXTILE INSTITUTE

Vol. XXXI AUGUST 1940 No. 8

PROCEEDINGS

NOTES AND ANNOUNCEMENTS

London Section

THE GENERAL SERVICEABILITY OF TEXTILES*

Serviceability is a word detested by the purists. It is not only involved and ill-sounding, but it has a range of implication rarely realised. Assessing serviceability is not simply a matter of testing for strength, shrinkage or colour-fastness. Many other important factors have to be considered.

The onus for securing serviceability in textiles falls first on the designer and maker of the fabric. Here scientific testing is necessary. A serious problem arises because of the lack of suitable standards of reference. A fabric may have a tensile strength of 50 lb. on a one inch strip. Is this strong enough for the conditions of use, and what margin of safety does it give? A colour may show only slight fading after exposure to 50 hours of sunshine. Is this good enough for out-door summer frocks or for furnishing fabrics?

These are not simple questions. In fact they are so involved that, if one looks too intently at the complications they will be given up in despair. Some investigators have to carry out scientific or technical research with the utmost precision; others have to use cruder methods and formulate as quickly as possible some rough, provisional, and approximate standards for guidance, slowly refining these as experience and information accumulate.

The method adopted in the speaker's laboratory was to test thoroughly all the fabrics obtainable that had failed in use. From the data thus obtained provisional standards were adopted, and year after year they were modified in accordance with new experience. Some of these are published in a paper on the " Serviceability of Fabrics " in the *Journal of the Textile Institute*, 1937, P225-232. This paper deals with shrinkage, tensile strength, bursting strength, thread slippage in fabrics, and has some remarks on wearing tests. Other standards are given in an article " Requirements of Colour Fastness in Actual Use " in the *Textile Manufacturer* of August, 1933.

A few illustrations of failures to consider serviceability on the part of the manufacturer may now be considered. First there is the matter of shrinkage or the contraction that takes place in fabrics that have been stretched in the finishing. This contraction occurs slowly with fabrics having the normal moisture content, more quickly if the goods are damp, and if immersed in water it may be complete in a few hours, or if in soap solution it may be complete in about an hour. The material reverts to the state in which it is free from strain. (A sample of gymnasium hose, excessively boarded in finishing, was shown.)

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*Abstract of a lecture to the London Section of the Textile Institute, March 15th, 1940, by J. G. Williams, Esq.

There is a blue dyestuff, Alizarine Saphirol, that is sensitive to salt. That is to say when a salt solution has dried on to the fabric the colour changes from a good blue to a grey. Perspiration contains salt, and if perspiration is absorbed by a fabric coloured with this dyestuff the colour is discharged. It may be argued that the dye should therefore not be used. If the salt is rinsed out the original colour returns, but when a frock has become discoloured under the arms the ordinary user does not know that in these cases simple rinsing is a cure. This salt solution test is useful in testing for fastness to perspiration. The obvious solution in terms of serviceability is not to use a dye with such properties for wool dress fabrics.

Another interesting example is provided by a violet coloured dyestuff which is very sensitive to changes in temperature. The colour change to red, is at its maximum at about 50° C., and this temperature is readily exceeded in materials exposed in summer sunlight. After a short period of out-door summer wear the parts exposed to sunlight will be a very distinct red; a person sitting at a window may have a frock partly red and partly violet. As the fabric cools the original colour returns. As an out-door clothing fabric this material has unserviceable colouring, but it has one possible use. The colour is not changed at 33° C., is slightly changed at 37° C., and is distinctly changed at 40° C. If worn by patients in hospital it might have serviceability, for when a fabric became red it would be known at once that the patient was feverish.

As a final example a tablecloth was shown. Owing to some constructional peculiarity the selvedge curls back over itself when the fabric is wetted. This means that in the calendering operation during laundering there is an irregular and double thickness at the selvedges, and in consequence wear occurs very quickly.

A factor of importance in service is the satisfying of the æsthetic and decorative requirements. Some will like and others will dislike a fabric because of the colour or the design, or because it is fashionable or because it is different from the prevailing fashion. It is not the present purpose to discuss this aspect of serviceability. But it should be emphasised that a really important feature of serviceability is the suitability of the fabric for the conditions under which it is to be used.

Exposure to sunlight in time deteriorates *all* fabrics. It is, however, serious with weighted silk fabrics and with rubber-coated or rubber-containing materials. It is well known that pure silk can be weighted with tin phosphate. In some crêpes de chine and satins, from one-third to two-thirds of the weight of the material may be due to this loading. Pure silk is reasonably resistant to sunlight tendering. From the speaker's tests it appears that light-weight silks require exposure to 150 hours of sunshine before half their strength is lost. But weighted silks only require 15 hours.

Experience shows that colours that will withstand 60 hours of sunshine with only a slight fading do not give trouble in garments for ordinary out-door wear. If slight fading occurs after 30 hours complaints of fading on frocks will be rare. But materials with colours that fade slightly after 15 hours are unsuitable for out-door wear and will prove very unsatisfactory. Thus the silk that loses half its strength in 15 hours will receive that degree of exposure or more during a season's wear. The Americans used to call weighted silk "dynamited silk" on account of the rapid perishing. Weighted silk in fact is unfit for out-door wear and is unfit for the tropics. It slowly perishes in ordinary daylight and so it is also unsuitable for embroidery work, etc., where durability is required. It is, however, quite satisfactory for nightwear or underwear.

Rubber perishes slowly by absorbing oxygen from the air, but the rate of deterioration is very much accelerated by sunlight. Mackintoshes should not be exposed to sunlight, and rubber-cored yarns are likely to be unsuitable and give poor service if unduly exposed.

Under humid conditions mildew stains may develop, and bacterial damage may be suffered by wet fabric. Only one material is resistant to the growth of mildew and to damage by bacteria and that is cellulose acetate. The reason, of course, is that it is not a naturally occurring material and so the scavenging agents of Nature have not discovered how to thrive on it. To show how the growth of mildew depends on the moisture content a sheet was exhibited. After washing it had been folded and put away while still very damp. The top and bottom and the edges of the folds dried out and were not appreciably affected. The rest of the fabric proved a happy culture medium for the spores of various moulds—mainly black, but some brown and others a bright yellow and a few red.

A factor in serviceability is proper care in cleaning treatments. Each textile fibre has its special properties, some desirable and some otherwise. The service given therefore depends on the cleaning being carried out with the care due to the nature of the material. Cotton can be cleaned by a boiling wash in soap and soda. Silk can also be cleaned in soap and soda, but it will become yellowed and tender if boiled.

Finally the serviceability of fabrics depends on the sense and care of the user. When camel-hair cloth coats were all the rage some year or so ago, customers often complained of the poor wear of the material. The surface had rubbed up into tufts of fibres and was very unsightly. One often gets similar complaints with wool dress cloths with a raised surface. The cure is a very simple one—treatment of the surface with a stiff-bristled clothes brush. It is not the material at fault, but the lack of proper care.

There are fabrics made specially for their appearance. For example, Angora fabrics have rabbit hair spun in with the wool and then the surface is raised so that the rabbit hair is prominent. Now it is an unfortunate property of rabbit hair that it does not bind well or key into yarns. Moreover, to get the desired handle and appearance, low twist yarns are used. When worn in reasonably fitting styles and without heavy coats over them these fabrics give satisfactory service. If worn in a close fitting style the arm friction in wear soon removes the rabbit hair surface, and then proceeds to thin the fabric. Wear under a jacket or heavy overcoat has similar unfortunate results.

If production were restricted to fabrics that are serviceable in all circumstances there would be only a small range of materials. The co-operation of many people is required if interesting and varied ranges of fabrics are to be available. The manufacturer must pay attention to testing his fabrics, and when any special treatments are necessary in the making up, or the care during use, or in the cleaning, he must pass on the information. The maker-up must co-operate by considering the suitability of the material in relation to the intended use of the articles, and the style of them. The retail distributor must have the necessary knowledge, and be so capable a sales-person as to pass it on efficiently. The launderer and dry-cleaner and re-dyer in their turn must study the special treatments to maintain the fabric in good condition.

APPARATUS FOR RAPID WEIGHING IN GRAINS

A. W. Bayes, M.Sc.Tech., F.T.I.

The following notes describe a simple method of adapting a chain drum device designed to weigh in grammes for weighing in grains.

When testing yarns in the cotton system it is convenient to measure the yarn in leas of 120 yards and to weigh in grains because the weight corresponding to the 120 yard lea is 1,000 grains and, therefore, the weight of a lea in grains can be converted to count by means of an ordinary table of reciprocals.

Analytical balances are commonly fitted with a chain device[1] which eliminates the need for small weights and provides for the balancing weight to be altered without lowering the beam, and an attachment[2] working on this principle is available for fixing to ordinary balances. The complete "Chainomatic" balances are expensive and more accurate than is necessary for routine yarn wrapping, and the attachment is made for weighing in grammes only. We find, however, that the attachment can be modified very simply to weigh in grains.

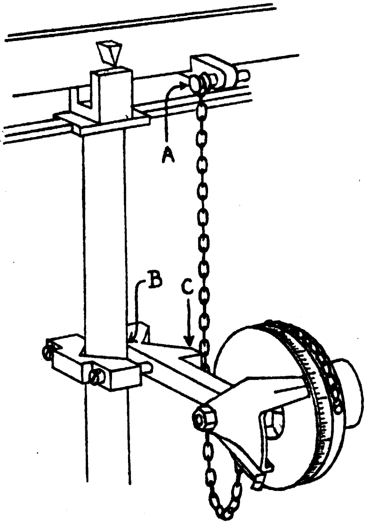

Fig. 1

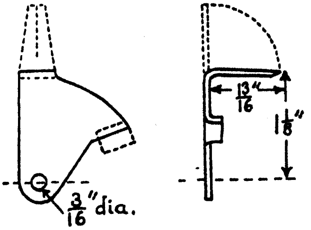

Fig. 2

The attachment consists of a chain suspended from an adjustable clamp on the balance beam and looped up to a graduated drum held in front of the balance on a horizontal spindle. The capacity of the drum is one gramme and the scale is numbered in decimals of a gramme. A weight of 10 grains is roughly three-fifths of the weight of 1 gramme, so if the chain peg on the balance beam is moved nearer to the balance fulcrum in this proportion and the drum is moved similarly to allow the chain to wind up correctly, the drum scale can be read as grains instead of decimals of a gramme.

The detailed modifications can be followed from Fig. 1 which represents the device arranged for weighing in grains. The chain peg A on the balance beam is screwed into its clamp from the left instead of the right to reduce the amount of adjustment of the compensating weight that would otherwise be necessary to balance the system, and the clamp itself is moved slightly to the left along the balance beam. The drum and bracket are taken to pieces and reassembled with the bracket turned over so that the balance pillar is gripped between the bridge of the clamp and the back of the bracket. The effect of this is to move the drum approximately as far towards the balance fulcrum as the groove of the chain peg has been moved so the chain continues to wind up correctly on the drum. The original pointer is fixed to the bracket and points the wrong way, so a new pointer is provided which may be cut and bent from sheet brass to the shape and dimensions shown in Fig. 2, the upper projection having a line engraved on it to form the new pointer and the whole being held in position by having the lower projection resting on the old pointer. Finally, the black pigment can be scratched out of the decimal points on the scale which now indicates up to 10 grains in decimals of a grain in divisions large enough to be read to 0·05 grains.

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[1] The Torsion Balance Company & C. A. Becker. B.P.100,737.

[2] Baird & Tatlock (London) Ltd. and H. H. Grainger. B.P.448,524.

The apparatus is adjusted in the ordinary way; the beam is balanced by raising or lowering the drum bracket and filing the compensating weight or moving the balance nuts on the beam, and the range is corrected by screwing the chain peg in or out of its clamp.

For some balances it may be necessary to file a little metal from the back of the bracket at B to make the chain wind up correctly, or on others to file metal from the projection on the bracket at C to allow the chain to hang straight, but usually these additional modifications are not required.

EDITORIAL BOARD

Publication of First Monograph

Members of the Institute who were present at the Annual Conference at Peebles in 1938 will remember the discussions which took place on "Education in Relation to the Textile Industries". Much comment was then made on the lack of books dealing with the fundamental sciences, such as physics, chemistry, mechanics and so on, and their application in textile work. This need has, from time to time, been strongly emphasised both by the teachers in the different textile schools and by the students themselves. The Council of the Institute, therefore, appointed an Editorial Board and it invited this Board to examine the problem and gave it the necessary powers to proceed with the preparation of certain monographs which might fill the need which had become so apparent. The problem which the Board has undertaken is, of course, a difficult one.

The Board, however, has fortunately had the benefit of the advice and help of many experienced members of the Institute, of the textile industry, of the schools and of the research associations. Although progress, in view of the inherent difficulty of the task, has been slow, it has nevertheless been made and the Board will shortly produce its first monograph. Mr. W. A. Hanton, M.Sc. Tech. of the College of Technology, Manchester, has written the first volume—"Mechanics Part I (The Study of Movement)". This volume, it is hoped, will be published early in September. The work will be completed by the publication of three subsequent parts, which will also be prepared by Mr. Hanton. Mention cannot be made individually of all who have given the Editorial Board assistance in its present work. The Board does feel, however, that it would like to record its appreciation of the help of Mr. J. Chirnside, of the College of Technology, Manchester, who has very kindly designed the cover for the first publication.

Reviews

Starch and its Derivatives. J. A. Radley, M.Sc., A.I.C. Monographs on Applied Chemistry No. 11. (London: Chapman & Hall Ltd., 1940, 346 pp. Price 22/-).

This book contains in a moderate compass a review of the chemistry of starch and its industrial applications. The first section, about one quarter of the whole, discusses the chemical constitution and properties, and includes a long chapter on the gelatinisation of granular starch and on related phenomena. Other sections deal with the manufacture of starch and starch products, their applications in the textile, paper, and other industries, the preparation of starch-splitting enzymes, and analytical methods. Each chapter has a bibliography and there are 61 photo-micrographs.

The chapter on physical properties describes several interesting investigations of the gelatinisation process by means of changes in consistency or opacity of starch pastes, which show clearly both the resemblances and differences between different botanical varieties. The causes of these differences are not yet understood but a full account is given of attempts to explain them based on fractionation experiments and on the effects of the minor constituents. There is however no discussion of the abnormal viscous flow of starch pastes.

As other adequate accounts are available, the manufacture of raw starch is described very briefly, but a more detailed account is given of the production of dextrins which embodies much of the author's own experience. An interesting feature of this process is the varying resistance of samples of the same or different varieties to conversion; the author ascribes this to differences in granule size distribution, but the evidence is inconclusive. The methods of acid and enzyme conversion are also described.

A detailed description of the operations of sizing and finishing textile goods is not attempted, but some account is given of general principles and of the properties of the various starch products in use. This account is disappointing. It does not refer to the importance of control of the amount of adhesive applied, whilst the discussion of sizes and finishes is confined to a few recipes and a collection of traditional and sometimes inaccurate opinions. A rational account of the behaviour of the starches in technical practice could have been developed by reference to scientific work described earlier in the book. This chapter includes three pages headed " Some Modern Developments in Printing Thickenings " which consist wholly of advertising matter.

The remainder of the book is of value chiefly as a collection of references; a large part of the text consists of brief abstracts of original papers or patents made to run consecutively and divided into paragraphs of convenient length. While this method of presentation may, as the author claims, give just weight to diverse views on controversial points, it presents no advantage to the reader over a collection of numbered and classified abstracts. A critical examination, in the light of modern conceptions, of the voluminous published work on starch, would have been more valuable to the specialist and technical chemist, and of more interest to the general reader. W. A. RICHARDSON.

Wool Year Book, 1940. Published by Textile Mercury Limited, 41, Spring Gardens, Manchester, 2. Price 7/6 net.

The annual appearance of such works as the one under review usually raises the question of the wisdom, desirability or necessity of publication every year. At such a time as the present, with shortage of paper and the other materials needed for books, there can be no justification for re-publication apart from the title " Year Book ". The brief review of the year could be left to the Imperial Economic Committee. The brutal fact must be faced that on rare occasions only is publication at intervals of less than three years advisable. The industries have arrived at a certain degree of stabilisation and any outstanding new developments can be adequately handled by the trade and technical press. Triennial publications containing surveys by responsible observers of the industry as a whole and embodying the recent developments would be valuable to the trade and would serve it quite as well as the present annual volumes changing comparatively little from year to year.

The above must be regarded as having general significance rather than particular application to the " Wool Year Book, 1940 ". This production maintains the high quality one has come to associate with " Textile Mercury " publications. Some of the useless half-tone illustrations could be omitted without loss, and even, if replaced by line drawings, with definite gain. Books of this type may be regarded from some points of view as reference text books which can be kept up-to-date more readily than those provided expressly for the instruction of students.

Applied Mycology and Bacteriology. L. D. Galloway, M.A., and R. Burgess, M.Sc., Ph.D. Second printing; 186 pages, 1940. (London: Leonard Hill Ltd. Price).

This useful book was reviewed at length in the *Journal,* 1938, Vol. 29, P.95. It is a pleasure to record that the authors have taken advantage of the remarks then made and at this second printing have revised the text in many small ways. They have also added to the lists of references to guide readers in a wider study of the subject and have introduced a few new illustrations prepared by themselves with the aid of microscope and camera. Outwardly, the book appears to be entirely new, but this is due to the fact that it is now printed on coarser paper and is thus one and a half times as thick as at the first issue.

J.C.W.

Addition to the Library

" Fibro " in the Worsted Industry. (Published by Courtaulds Ltd.).

In this 69-page booklet is much that will be of great value and interest to those engaged in the worsted industry. The matter is very clearly presented. This applies particularly to the graphs in which yarn strengths, etc., are shown in contrast with those of wool.

Textile Institute Competition Awards, 1940

The Competitions conducted annually by the Textile Institute have again attracted a large number of entries. Prizes provided by the Crompton Memorial Fund, the Beanland Bequest, and other donations have been awarded for Woven Fabrics, Knitted Fabrics, Yarns and Designs for Printed Fabrics, produced by British students at Technical Colleges and Schools in Great Britain and N. Ireland.

Details of arrangements for the Prize Distribution will be published later.

The awards and names of successful candidates are as follows:—

(A) Competition: Woven Fabrics

First Prize (£25 & Certificate)...	D. L. Mercer (Burnley Municipal College)
Second Prize (£15 & Certificate)	No award
Equal Third Prizes (£10 & Certificate) ...	Miss M. I. Pye (Blackburn Technical College) J. Whittle (Bolton Technical College)
Prizes of £4 each ...	W. Dobson (Burnley Municipal College) M. Potter (Leeds University) P. Thornton (Leeds University)

(B) Competition: Yarns

Class I: Novel Folded Yarns

First Prize (£5)	L. Carbutt (Bradford Technical College)
Second Prize (£3)... ...	G. Robinson (Bradford Technical College)

Class II: Novel Single Yarns

First Prize (£3)	L. Carbutt (Bradford Technical College)
Second Prize (£2)... ...	G. Robinson (Bradford Technical College)

(C) Competition: Special Woven Fabric

First Prize (£5)	W. E. Butterfield (Dewsbury Technical College)
Second Prize (£4)... ...	A. T. Good (Blackburn Technical College)
Third Prize (£3)	L. Duxbury (Accrington School of Arts and Crafts)
Fourth Prize (£2) ...	M. Potter (Leeds University)

(D) Competition: Woven Fabric

First Prize (£3)	J. H. Rushton (Burnley Muncipal College)
Second Prize (£2)... ...	G. Preston (Manchester College of Technology)
Prizes of £1 each... ...	J. A. Barker (Burnley Municipal College) Mrs. A. Bowdin (Burnley Municipal College) H. T. Bucknell (Rochdale Technical School) J. Varley (Accrington Technical School) E. S. Woodhall (Bradford Technical College)

(E) Competition: Knitted Fabric

First Prize (£5)	... A. W. Marvin (Leicester College of Technology)
Second Prize (£3)... ...	... R. Duffey (Leicester College of Technology and Commerce)
Third Prize (£2)	... Miss R. Land (Nottingham University College)
Prizes of £1 each... ...	... Miss S. Fisher (Nottingham University College) Miss J. Spencer (Leicester College of Art and Technology) Miss V. F. Waterhouse (Nottingham University College)

(F) Competition: Designs for Printed Fabrics

Class I: Dress Materials

First Prize (£6)	... E. Sharp (Manchester School of Art)
Second Prize (£4)... ...	... Miss J. Davison (Manchester School of Art)
Third Prize (£2 10s.) ...	... Miss H. P. Jago (Manchester School of Art)

Class II: Furnishing Fabrics

First Prize (£5)	... L. O. Baxter (Belfast College of Art)
Second Prize (£4)... ...	... E. Anderson (Bradford Technical College)
Third Prize (£2 10s.) ...	... D. Bentley (Bradford Technical College)

(G) Competition: Special Woven Fabric (Worsted)

Class I: Men's Wear

First Prize (£3)	... T. C. Fletcher (Halifax Technical College)
Second Prize (£2)... ...	... L. Armitage (Huddersfield Technical College)
Third Prize (£1)... ...	... T. Moore (Keighley Technical College)

Class II: Women's Wear

First Prize (£3)	... D. Young (Bradford Technical College)
Second Prize (£2)... ...	... H. L. Stretton (Bradford Technical College)
Third Prize (£1)... ...	... W. D. Joy (Bradford Technical College)

(H) Competition: Woven Fabric (Worsted)

First Prize (£3)	... D. H. Pearson (Huddersfield Technical College)
Second Prize (£2)... ...	... W. Watkins (Bradford Technical College)
Prizes of £1 each ...	... J. Bullock (Bradford Technical College) A. Hasdell (Halifax Technical College) F. B. Murgatroyd (Leeds University)

Textile Institute Diploma

EXAMINATION RESULTS, 1940

In the Examinations for the Associateship of the Textile Institute held in May, 1940, at Belfast, Bradford, Dunfermline, Leicester, London and Manchester, the following candidates were successful:—

Preliminary Examination:

*R. A. Bailey (Burnley)
*E. Cropper (Bradford)
C. Norcliffe (Huddersfield)
*F. C. Brown (Derby)
*J. B. Lancashire (Leicester)
Essay only—T. Fraser (Dunfermline)

Examination in General Textile Technology:

*H. Arnold (Bolton)
G. A. Baxandall (Leicester)
J. Boyd (Manchester)
*D. J. Burton (Leicester)
*H. Castle (Huddersfield)
T. Flynn (Blackburn)
W. Hamilton (Macclesfield)
*N. Jackson (Belfast)
*A. Mills (Middleton)
*H. Newton (Huddersfield)
*L. W. Oldham (Bradford)
*A. E. Reveley (Leeds)
*J. Senior (Dewsbury)
*H. Wild (London)
*R. A. Bailey (Burnley)
*R. Birch (Middlesex)
*F. C. Brown (Derby)
*G. Bury (Bolton)
N. N. Fearn (Beeston)
*J. Greenwood (Bradford)
*J. Hodgson (Dewsbury)
*J. B. Lancashire (Leicester)
*W. Morris (Heanor)
C. Norcliffe (Huddersfield)
*D. W. Poxon (Loughborough)
*M. G. Sarkar (Blackburn)
*H. B. Skaife (Keighley)
R. Wilks (Shipley)

Names marked with an asterisk are of candidates who have completed the qualification requirements for the award of Associateship (A.T.I.).

Examination in Analysis and Testing of Textile Materials:

J. E. Caffyn (Reading)

TEXTILE INSTITUTE DIPLOMAS

Elections to the Fellowship and the Associateship of the Textile Institute have been completed as follows, since the appearance of the previous list (June issue of the *Journal*):—

FELLOWSHIP

HENRY ALEXANDER JAMES DUNCAN, A.T.I.,
Works Departmental Manager, Knowles Ltd., Bolton.

JOHN BOWMAR LANCASHIRE, A.T.I.,
Lecturer, Leicester College of Technology.

ENOCH SWAN, M.Sc., A.T.I.,
Chairman and Governing Director, Swan & Haslam Ltd., Bolton.

ARTHUR JAMES TURNER, M.A., D.Sc.,
Head of Spinning Department, British Cotton Industry Research Association, Manchester.

JOHN ROSE WALKER, Director, McLeod & Co. Ltd., Calcutta.

SIDNEY ARTHUR WELCH, B.Sc., A.I.C.,
Knitted Fabrics and Garments Manager, British Celanese Ltd., London.

ASSOCIATESHIP

HERBERT ARNOLD.
ROBERT ATKINSON BAILEY.
RONALD BIRCH.
FRED CARTER BROWN.
DONALD JOSEPH BURTON.
GRAHAM BURY.
HUBERT CASTLE.
TREVOR CRAWSHAW.
JIM GREENWOOD.
JOE HODGSON.
NORMAN JACKSON.
ANGUS ALEXANDER MACDONALD
WILLIAM MORRIS.
HARRY NEWTON.
LESLIE WILLIAM OLDHAM.
DENIS WILL POXON.
ALBERT EDWARD REVELEY.
MAHADEY GOBIND SARKAR.
JACK SENIOR.
HENRY B. SKAIFE.
HARRY WILD.

OBITUARY

Colonel F. R. McConnel

In the passing of Colonel McConnel the Textile Institute has lost a great member and one whose persistent effort and energy did much to establish the position of the Institute in its early years. He was a Founder member and at an early date became a Life Member. The offices he held were important and noteworthy: Member of the Council, Honorary Treasurer succeeding the late Mr. Cedric Lee and remaining in the office until his military duties called him away in 1914.

He was elected a Vice-President in 1917 and in 1920 succeeded the late Sir A. Herbert Dixon, Bart., as President, remaining in office till the end of 1921. He was also Chairman of the Council so it will be appreciated that he occupied almost every possible office during a comparatively brief period. He was a liberal subscriber to our Foundation Fund.

In 1930 he was honoured by the award of the Institute Medal.

Only those who worked with him can appreciate his practical forthright methods. He had no time for discursive talking, and his keen appreciation of a point at issue enabled decisions to be quickly reached, an invaluable asset at a time when the Institute was finding its feet and founding its position. He was a ready and forceful speaker. A tinge of the military, perhaps, but from him you got a plain statement of fact without any trimmings. He served the Institute well, and it is good that his service was fully recognised during his lifetime. Undoubtedly he was one whose name is fully worthy of inscription on any Roll of Service the Institute may set up. F. NASMITH.

Mr. Herbert W. Lee

By the death of Mr. Herbert W. Lee the Institute has lost another of its Founder Members.

Mr. Lee did not take a very active part in the work of the Institute. The best of his life was given to the Fine Cotton Spinners' & Doublers' Association Ltd., of which he became a director in 1898, an executive director in 1905, chairman of executive directors and managing director in 1917 and working chairman in 1922. He served the industry in many other ways.

When other memories have become dim, Mr. Lee will probably be remembered for his work in connection with the welfare organisations in the mills of the Association.

NOTICES: INSTITUTE MEETINGS

Tuesday	3rd September	*Manchester*—1.15 p.m. Meeting of the Diplomas Committee at the Institute.
Tuesday	3rd September	*Manchester*—2.45 p.m. Meeting of the Publications Committee at the Institute.
Friday	6th September	*Manchester*—2.30 p.m. Meeting of the Committee on Recruitment, Selection and Training of Textile Operatives, at the Institute.
Wednesday	18th September	*Manchester*—2.0 p.m. Meeting of the Finance and General Purposes Committee at the Institute.
Wednesday	18th September	*Manchester*—2.45 p.m. Meeting of the Council at the Institute.

MIDLANDS SECTION

Wednesday	11th September	*Coventry*—7.0 p.m. Three lectures on "Coventry's Textiles"; "Ribbons and Smallwares" by Mr. L. J. Clarke, B.Com., "Synthetic Fibres, Past and Present" by Mr. G. Loasby, B.Sc., F.I.C., "Textiles in the Electrical Trade" by Mr. R. I. Martin, A.M.I.E.E. The meeting will be held in the Rex Banqueting Hall, Corporation Street, and the Chair will be taken by Mr. W. Pritchard, F.T.I.

LANCASHIRE SECTION

Thursday,	26th September	*Manchester*—6.45 p.m. Opening Lecture—"Designing for Furnishing Fabrics for Overseas Markets" by Mrs. L. Fraser at the Institute.

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TEXTILE INSTITUTE

Vol. XXXI SEPTEMBER 1940 No. 9

PROCEEDINGS

NOTES AND ANNOUNCEMENTS

REPORT OF THE EXAMINATIONS BOARD, 1940

Preliminary Examination

The examiners in both chemistry and physics find evidence that candidates have had insufficient practice in laboratory work; the Board wishes to stress the value of practical work in the training of the student.

Mechanics, which is of fundamental importance to most branches of textile technology, is almost invariably weak. Whilst this may be due to the absence of the subject from some day school curricula, it is on that account all the more important that it should receive special attention in the early years of the technical courses.

Examination in General Textile Technology

It is the common experience of examiners that standards of spelling, grammar, composition and style in the answers presented by candidates are low. Members of the Institute who are awarded the Associateship are thereby recognised as textile technologists, and as such are expected to be qualified to give assistance and advice in problems which arise in the textile industry. It is not sufficient that Associates should have the necessary technical knowledge; they should at the same time be capable of imparting that knowledge in a lucid manner whether verbally or in writing. The examiners propose to attach greater importance to the standard of English shown in the candidate's work.

The tendency of candidates merely to recapitulate lecture notes when formulating replies to questions is also generally reported by the examiners. Whilst factual knowledge is necessary, it is not less important that candidates should be able to apply such knowledge in reasoned answers. Candidates are urged to exercise themselves in the application of their knowledge rather than in acquiring merely the ability to reproduce lecture notes.

The Board is aware of the lack of suitable textbooks in textile technology, but it cannot accept this as an excuse for the persistence of out-of-date ideas or for failure to keep abreast with modern developments. The results of this examination indicate that, both in teaching and in individual study, insufficient attention is being given to the results of recent research published in the Institute's *Journal* and elsewhere.

EXAMINATION IN GENERAL TEXTILE TECHNOLOGY

SECTIONS I AND V OF SYLLABUS

10 *a.m. to* 1 *p.m.—29th May,* 1940

Candidates to answer THREE *questions in* EACH *Section*

Section I—Fibres and their Production

(1) With respect to any one of the natural textile raw materials, discuss the fibre characteristics and other features which determine its value. Regard should be had not only to the quality of the yarn that can be spun from it but also to the processing cost.

(2) Which fibres can be described as " artificial " and which as " synthetic " ? Give brief outlines of the origins and production of the fibres mentioned.

(3) Give the origin of flax and jute. Describe the main characteristics of the fibres, pointing out the microscopic features and chemical reactions which enable them to be differentiated.

(4) Discuss (*a*) the properties of viscose staple fibre regarded as a possible substitute for cotton, and (*b*) the properties of casein fibre regarded as a possible substitute for wool.

Section V—Analysis and Testing of Raw Materials, Yarns and Fabrics

(5) Describe fully the method of determining the degree of degradation or chemical change in cotton goods by measurement of the cuprammonium fluidity of the cotton.

(6) What defects in fabrics are attributable to the following :—

(*a*) A heald shaft too low.
(*b*) A broken peg in a dobby chain.
(*c*) Irregular count of the weft yarn.
(*d*) Periodic variations in yarn twist.

(7) Compare the results obtained when testing a warp yarn by (*a*) the lea method, (*b*) the single thread method. Which do you consider gives the better indication of the weaving property and why ?

(8) Explain how failure to take account of the moisture content of textile materials may result in serious financial loss (*a*) in the case of a spinner, and (*b*) in the case of a manufacturer. Describe in its essential details the procedure you would adopt to determine the " conditioned weight " of any given sample of textile material, supposing that a constant humidity chamber is not available.

(9) Describe how you would prepare a sample for fibre length measurement to be made on (*a*) loose fibre, and (*b*) top, sliver, roving, or yarn. Give reasons for the procedure you would adopt.

SECTIONS II, III AND IV OF SYLLABUS

2.30 *p.m. to* 5.30 *p.m.—29th May,* 1940

Candidates to answer TWO *questions in* EACH *Section*

Section II—Conversion of Fibres into Finished Yarns

(1) Analyse and compare the functions of the card and the comb (comber). What effect has combing on (*a*) the subsequent processes in spinning, and (*b*) the character and quality of the yarn produced?

(2) Explain why the following are favoured: (*a*) mule spun as against ring spun fine cotton yarns; (*b*) flyer spun as against cap spun worsted hosiery yarns; and (*c*) " wet " spun as against " dry " spun flax yarns? How do these related yarns compare in cost of spinning?

(3) Explain with the aid of sketches how the yarn is twisted and wound on the cop or bobbin in the following machines; (*a*) mule, (*b*) ring frame, (*c*) cap frame. State in each case how you could increase the tension of the yarn during winding.

(4) Why is twist generally essential to the making of a yarn? Are there exceptions? What conditions determine the amount of twist to be inserted?

(5) Describe the usual method of scouring greasy wool, indicating the scientific principles involved, and the precautions which must be taken to minimise felting.

Section III—Conversion of Yarns into Fabrics, and Fabrics produced by Special Methods

(6) Describe a bearded or spring needle and explain how a course of loops is produced on any type of machine using this needle?

(7) Warp yarns for weaving are generally passed through the three preparatory processes of (*a*) winding, (*b*) warping, (*c*) sizing. What are the objects of each of these processes? Explain how any one of the processes is carried out, stating the kind of yarn assumed.

(8) What factors decide which of the three loom types (*a*) tappet, (*b*) dobby, (*c*) jacquard, is used for weaving any particular cloth?

(9) Discuss briefly the use of two or more warp beams for the same loom when weaving a given fabric. Give two examples to show weave or structure of certain fabrics requiring more than one beam for the complete set of warp threads.

Section IV—Conversion of Fabrics into Finished Materials

(10) Describe clearly a method of producing (*a*) an increased permanent lustre on good quality Egyptian cotton yarn and (*b*) a high temporary lustre on medium quality Aniline Black dyed lining cloth. Discuss the underlying principles upon which the production of the requisite effects is based.

(11) What types of material are subject to milling? What are the objects of the process? Describe fully the methods of milling, and attempt an explanation of what actually takes place in the process.

12) Animal and vegetable fibres in the raw state are often found to be associated with non-fibrous substances or " impurities." Discuss the importance of these non-fibrous substances in relation to subsequent bleaching, dyeing and finishing processes, and describe methods of removing them in the case of one textile fibre.

(13) What is a dyestuff? How does it differ from a pigment? How are dyestuffs classified by the practical dyer? Name the classes of dyestuffs which you regard as outstanding for ease of application, bright clear shades, and high degree of fastness to washing when dyed on one of the following textile fibres:—

(*a*) Wool.
(*b*) Cotton.
(*c*) Viscose Rayon.
(*d*) Silk.

ANALYSIS AND TESTING OF TEXTILE MATERIALS

Section A

Wednesday, April 24th, 7 to 10 p.m.

Not more than FIVE *questions to be attempted. The answer to each question attempted must be commenced at the top of a right-hand page in your answer book. You must write your examination number at the top of each page upon which you begin an answer.*

(1) With the aid of simple sketches, show the external microscopic appearance of the following fibres:—(*a*) Merino wool, (*b*) cotton, (*c*) mohair, (*d*) cuprammonium rayon, (*e*) viscose rayon.

Explain the importance of the characteristic features of each of these fibres.

(2) What economic factors have stimulated the developments of Lanital in Italy and Nylon in America? To what extent can these materials be used as substitutes for natural fibres? What producing countries are likely to be adversely affected by such substitution?

(3) State what you know of the fundamental structure, chemical composition, and characteristics of flax, hemp, jute, and ramie fibres, emphasising the properties which determine their spheres of usefulness.

(4) What is meant by the term "fluorescence"? Give a critical account of the use of fluorescence phenomena in the solution of textile problems.

(5) Discuss the importance of humidity control in measuring yarn count, bearing in mind that the measurement of length as well as of weight is involved.

(6) Explain how and why the apparent strength of a yarn depends on the length of the specimens tested. State, giving reasons, what length of specimen you would use to obtain the most discriminating measure of variability in yarn strength.

(7) How would you proceed to measure the amount of shrinkage a cotton fabric would be likely to undergo during laundering? Give an outline of the commercial processes in use for the elimination of such shrinkage in manufactured materials.

(8) Discuss (*a*) the uses and limitations of the bursting test as a method of measuring fabric strength, and (*b*) the structural features of a cloth which determine its bursting strength.

(9) Write a short essay on the difficulties of devising a general purpose wear test which will enable any two fabrics to be compared for their probable durability in service.

Section B

Friday, April 26th, 7 to 10 p.m.

Not more than FIVE *questions to be attempted. The answer to each question attempted must be commenced at the top of a right-hand page in your answer book. You must write your examination number at the top of each page upon which you begin an answer.*

(1) What raw materials would you recommend for the manufacture of (*a*) brake linings, (*b*) blankets, (*c*) calicoes, (*d*) gent's socks, (*e*) table napery, (*f*) ladies' stockings? Give reasons in justification of your selection in each case.

(2) Describe in detail how you would ascertain the percentage composition of a cloth containing wool, cotton, and viscose rayon yarn.

(3) Give the exact details of the method you would adopt in order to estimate the percentage of starch, and of china clay, in a cloth which has been filled with a mixture of these two.

(4) Tests on textile materials are nearly always limited to tests on samples thereof. Describe in detail, and give reasons for, the procedure you would adopt to obtain a representative sample from—

- (*a*) A wool or cotton yarn for the determination of fibre length.
- (*b*) A spool of sewing thread for determining its uniformity in thickness.
- (*c*) A piece of cloth for determining its weft-way breaking strength.

(5) How would you test a coloured casement fabric with the object of establishing its suitability or unsuitability for use in window curtains?

In what respects do you consider your method of testing is open to criticism?

(6) Discuss the respective fastness requirements of the coloured portions of the following materials:—

- (i) Striped cotton poplin shirting.
- (ii) Silk crêpe de chine for evening dress wear.
- (iii) Rayon lingerie.
- (iv) Navy blue serge for men's suitings.

(7) The following agencies are known to cause damage to textile fabrics:—

- (*a*) Mildew.
- (*b*) Oxidising agents.
- (*c*) Alkalis.

Write short notes on each, stating the conditions under which each type of damage usually occurs, the type of textile materials usually affected, and the methods by which you would confirm the cause of damage.

(8) Discuss the agencies which lead to the deterioration in use of—

- (*a*) Linen table napkins.
- (*b*) Wool vests,
- (*c*) Vat dyed viscose casement fabrics.
- (*d*) Jute sandbags.

(9) Write an essay on the relations between the measurable physical characteristics of fabrics, and the utility of the fabrics *either* for clothing, *or* for furnishing.

SECTION PROGRAMMES, 1940-41*

Date.	*Title.*	*Lecturer.*	*Place.*	*Chairman.*
	LANCASHIRE SECTION			
Friday, 8th Nov., 6.0 p.m.	"Finishing Machinery Developments."	K. S. Laurie, Esq.	Old Boar's Head Hotel, Bury.	H. Warburton, Esq., President Bury Textile Society.
Thurs., 12th Dec., 6.0 p.m.	"Shortage, Selection and Training of Textile Operatives."	H. Rostron, Esq.	Oldham Municipal Technical College.	B. Shore, Esq., Chairman, Oldham Technical Association.
1941.				
Thurs., 27th Feb., 6.0 p.m.	Members' Evening. "The Importance to Weavers of Correct Leasing of Acetate Warps."	R. Yates, Esq.	The Institute, Manchester.	F. Nasmith, Esq., F.T.I.
Wednes. 19th Mar., 6.0 p.m.	Annual Meeting.	—	The Institute, Manchester.	W. English, Esq., M.Sc. (Tech.), F.T.I.
Thurs., 27th Mar., 6.0 p.m.	"The Fluidity of Silk Solutions as a Measure of Quality."	Dr. F. O. Howitt, M.Sc., Ph.D., F.I.C., F.T.I.	Technical School, Macclesfield.	W. R. Wadsworth, Esq.
Thurs., 3rd April, 6.0 p.m.	"Twistless and Low Twisted Yarns."	A. Draper, Esq.	Municipal Technical College, Bridgeman Place, Bolton.	W. Howarth, Esq., F.T.I.
	YORKSHIRE SECTION			
Thurs., 3rd Oct., 7.0 p.m.	"Prize Distribution," followed by Smoking Concert.	J. Crompton, Esq., O.B.E., M.Sc. (Tech.) F.T.I.	Midland Hotel, Bradford.	H. Hardy, Esq., A.T.I.
Thurs., 17th Oct., 7.0 p.m.	"The Public Health" (Drainage of Trade Premises) Act, 1937."	J. H. Garner, Esq., B.Sc., F.I.C., M.I.Chem.E. (Chief Inspector of the West Riding of Yorkshire Rivers Board)	Midland Hotel, Bradford.	H. Hardy, Esq., A.T.I.
Thurs., 21st Nov., 7.0 p.m.	Lecture—Subject to be announced later.	Prof. J. B. Speakman. D.Sc., F.I.C., F.T.I. (Dept. of Textile Industries, Leeds University).	Midland Hotel, Bradford.	H. Hardy, Esq., A.T.I.
Thurs., 12th Dec., 7.0 p.m.	"Excess Profits Tax."	V. Walton, Esq., F.C.A. (Messrs. Victor Walton & Co.).	Midland Hotel, Bradford.	H. Hardy, Esq., A.T.I.
1941.				
Thurs., 23rd Jan., 7.0 p.m.	A.T.I. Evening.	—	Midland Hotel, Bradford.	H. Hardy, Esq., A.T.I.
Thurs., 20th Feb., 7.0 p.m.	"Industrial Psychology."	B. Ungerson, Esq., B.Econ. (National Institute of Industrial Psychology).	Midland Hotel, Bradford.	H. Hardy, Esq., A.T.I.
Thurs., 20th Mar., 7.0 p.m.	Ladies' Evening, "Popular Photography."	R. R. Rawkins, Esq., (Ilford, Ltd.).	Midland Hotel, Bradford.	H. Hardy, Esq., A.T.I.
Thurs., 27th Mar., 7.0 p.m.	Annual Meeting.	—	Midland Hotel, Bradford.	H. Hardy, Esq., A.T.I.

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* *It was hoped that it would be possible to produce at the same time the programmes of all the Regional Sections Unfortunately, the Midlands, London, Irish and Scottish Sections have been unable to make arrangements in advance. If subsequent arrangements are made for lectures notification will appear in the Journal and members will be circularised.*

Frank Wright Memorial Fund.

The late Mr. Frank Wright spent his life in the Cotton Industry and his work was well known to all engaged in cotton spinning, doubling and twisting. He was profoundly interested in the Textile Institute which he served for many years as a member of Council and of various standing Committees. In order to establish a memorial to him, which will be known as the "Frank Wright" Memorial Fund, Mrs. Wright has transferred to the Institute £1,000 of 3½ per cent. War Stock.

After long and careful consideration it has been agreed that the income from the Fund shall be used to encourage and assist investigation in cotton spinning, doubling and twisting, as this was the section of the industry to which Mr. Wright devoted so much of his time and energy.

Applications for assistance from the Fund will be invited from suitably qualified persons of British nationality without age restriction. Candidates will be asked to formulate a programme showing the work which they propose to undertake, and awards will be made annually or at such other intervals as the Council of the Institute may decide. Successful applicants will be able to use the grant to meet the cost of special materials, equipment, travel or other facilities incurred directly in connection with the investigations made. Grantees will be required to work under the supervision of a Professor, Teacher, or other person of standing approved by the Institute.

Further information will be published later giving details of the way in which applications for grants should be made.

Lancashire Section

"PERSONALITY—A MAN AND HIS WORK"*

The lecturer dealt with his subject from the practical, rather than the purely scientific, point of view of the man in the works, the foreman or the works manager, dealing with the reaction, upon anyone who meets him, of his personality as assessed by his physical and mental characteristics.

With regard to the physical, he stressed the importance of "presence", with all that it implies in tone and voice, general bearing, mannerisms, etc. But he assessed mental make-up as of greater importance, as being less subject to modification by systematic training. In approaching this aspect of his subject the lecturer gave a critical survey of the mechanism of the mind, dealing with sensation under the process of sensual impression, nerve messages, identification of mental impressions and the functioning of muscular action under those impressions. From the analysis of these sensations and their reactions the lecturer showed the evolution of habits and the importance of "thought control" or the "power of concentration". Having outlined the subject of psychology from the standpoint of natural and acquired personality, the lecturer dealt with the development of natural faculties—such as the "card-index mind", the "cinematograph mind", and the power of revisualising past happenings accurately and grasping possible eventualities.

He stated that while the natural possibilities can always be emphasised by training, educational development is mainly a question of study, and he illustrated his point in the cases of the professional man, the technician, the craftsman and the tradesman.

In applying his analysis of personality from the viewpoint of industry, or rather "the manner in which the employer looks upon it", the lecturer regretted that in too many cases "no account is taken" of the mental and physical capacity of the man to operate a new machine, and he illustrated this point in the physical and mental requirements of certain technical jobs, e.g. bobbin wind, and argued that the principle might be applied to executive, technical and administrative positions in the same way, on the ground that jobs can be defined and classified.

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* Abstract of a lecture given by G. E. Wilson, B.Sc., F.C.S., to the Lancashire Section of the Textile Institute, 20th March, 1940.

The lecturer then dealt with the matter of " selection " of staff, by reference to the guiding principles of selection. He discussed psychological methods of testing applicants, the application of operation tests, including tests for colour blindness, etc.

Subsequently the lecturer dealt with the training of staff " functionally selected " and stressed the value of production results.

Finally the lecturer discussed the service which is and might be rendered by the Labour Exchange in any particular locality.

The lecturer aroused an interesting and helpful discussion which showed the great appreciation of the service rendered to the members by Mr. Wilson.

Institute Diplomas

Elections to the Associateship have been completed as follows since the appearance of the previous list (August issue of the *Journal*):—

JALOTA ONKAR LAL.
HERBERT BRIAN BRADLEY.
GEORGE HENRY HOTTE.
ALBERT MILLS.

Correction

The announcement regarding the Fellowship award to H. A. J. Duncan, Esq., should read:—

" HENRY ALEXANDER JAMES DUNCAN, Esq., A.T.I.,
Works Departmental Director, Horrockses, Crewdson & Co. Ltd., Preston and Bolton,"

and not as printed in the August issue of the *Journal*.

NOTICES: INSTITUTE MEETINGS

Tuesday	1st October	*Manchester*—1.15 p.m. Meeting of the Publications Committee at the Institute.
Tuesday	1st October	*Manchester*—2.45 p.m. Meeting of the Diplomas Committee at the Institute.
Wednesday,	16th October	*Manchester*—2.0 p.m. Meeting of the Finance and General Purposes Committee at the Institute.
Wednesday,	16th October	*Manchester*—2.45 p.m. Meeting of the Council at the Institute.
Wednesday	23rd October	*Manchester*—2.30 p.m. Meeting of the Joint Committee re National Certificates in Textiles.
Friday	25th October	*Manchester*—2.30 p.m. Meeting of the Committee on Recruitment, Selection and Training of Textile Operatives, at the Institute.

YORKSHIRE SECTION

Thursday	3rd October	*Bradford*—Prize Distribution to be held at the Midland Hotel, Bradford, at 7.0 p.m., to be followed by a Smoking Concert. Prizes will be distributed by J. Crompton, Esq., O.B.E., M.Sc.Tech., F.T.I. Chairman: H. Hardy, Esq., A.T.I.
Thursday	17th October	*Bradford*—Lecture: " The Public Health (Drainage of Trade Premises) Act, 1937 " by J. H. Garner, Esq., B.Sc., F.I.C., M.I.Chem.E. (Chief Inspector of the West Riding of Yorkshire Rivers Board), at the Midland Hotel at 7.0 p.m. Chairman: H. Hardy, Esq., A.T.I.

OTHER ORGANISATIONS

Blackburn Textile Society.

Friday	11th October	*Blackburn*—Opening Meeting. Address by the President, H. de G. Gaudin, Esq., on "Automatic Weaving—To-day and To-morrow."
Friday	25th October	*Blackburn*—Lecture: "Recent Developments in Textile Finishing as a Means for Improving the Production of Fabrics" by A. J. Hall, Esq., B.Sc., F.I.C., F.T.I.

Bradford Textile Society.

Monday	7th October	*Bradford*—Annual Address by The Rt. Hon. Leslie Burgin, LL.D., M.P., at the Midland Hotel, at 7.0 p.m.
Monday	21st October	*Bradford*—Presidential Address by Alderman Walter Hodgson, J.P., at the Midland Hotel, at 7.0 p.m.

Reviews

Fluorescence Analysis in Ultra-Violet Light. J. A. Radley, M.Sc., and J. Grant, Ph.D. Series of Monographs on Applied Chemistry, Vol. 7. (Edited by E. Howard Tripp, Ph.D. 3rd Edition. Pages XVI and 424. London: Chapman & Hall, 1939. War Price 25/-).

The demand for a third edition of this work soon after the publication of the previous editions is, as the authors observe in their preface, a clear indication of the continued interest in the subject of fluorescence analysis.

The present edition is almost twice the size of the original. It embodies a large number of additional references to, and descriptions of, published work (including the most recent) dealing with the application of ultra-violet fluorescence in the identification and testing of a wide range of products. The full bibliography given at the end of each chapter renders the book of very considerable value in directing the reader's attention to published papers concerned with the application of fluorescence analysis to the subject in which he is interested.

In view of the somewhat empirical nature of the fluorescence test as an aid in analysis, it is difficult to avoid a "catalogue" presentation of the large number of observations which have been made by the many workers in this field and much of the information has to be presented in too condensed a form to make easy reading. It is felt, however, that especially in the introductory chapters of this book dealing with the general principles, greater ease of reading could have been achieved.

The application of ultra-violet fluorescence in the testing of textile materials has shown that, provided the limitations of the test are realised, much valuable information can at least be indicated. It is satisfactory to note that much useful material has been added to the chapter on textiles and that the section on dyestuffs, which are of paramount interest to the textile technologist, now occupies a separate chapter.

In view of the ever-growing fund of information regarding the application of ultra-violet fluorescence in analytical work and the possibility of future editions of the book becoming unwieldly, the authors might consider it desirable to split up the work into a number of smaller publications.

A separate monograph dealing with the ultra-violet examination of textile materials including dyestuffs, oils, etc., which are of importance in this connection, would be of very considerable interest to the textile technologist. A separation publication of this sort would enable sufficient consideration to be given to the subject to avoid any undue tendency to scrappiness in the presentation of the material.

D.A.D-S.

Cotton Year Book, 1940. (Published by Textile Mercury Limited, 41, Spring Gardens, Manchester 2. Price in Great Britain 7/6 net, Abroad 8/6 net).

In war time the sources of commercial and industrial statistics naturally tend to dry up as a result of Government action to prevent information of value going to the enemy. This affects such publications as the "Cotton Year Book".

The principal changes made, apart from those in the statistical section, are in the portion devoted to weaving. This section has been revised and extended and greater attention has been given to automatic looms. T.

The Textile Recorder Year Book, 1940. (Published by the Harlequin Press Co. Ltd., Old Colony House, South King Street, Manchester. Price 10/6 net).

The Foreword to "The Textile Recorder Year Book, 1940" contains a reference to these "times of change and uncertainty". The publishers must have been relieved when the work was completed.

Apart from the difficulties imposed by war conditions, no appreciable changes were to be expected. Compared with the 1938 Edition the most noticeable alterations are the thumb-indexing and the sectional page numbering instead of the continuous numbering. The usual high standard of the production is well maintained and the lack of mention in detail should not be read as non-appreciation. T.

Additions to the Library

Annual Journal of the National Federation of Textile Works Managers' Associations, 1939-1940. Vol. XIX. (Published by "The Textile Weekly".)

"**Bibliography of the Cotton Industry.** W. Threlfall, F.L.A., Chief Librarian, Stretford Public Libraries. (Typescript).

[NOTE.—This work was compiled by the author as a thesis for the Honours Diploma of the Library Association. It is given on condition that no part is published without the author's consent and that the manuscript may be returned to the author if he should be able to continue the revision. The Chairman of the Library Committee has gratefully accepted the gift on behalf of the Council on these terms.]

Institute Membership

Ordinary.

Dale, Terence Rupert Moore, "Dunwich," 217, Reepham Road, Norwich. Buyer, Linen and Furnishing Fabrics, Messrs. Garland & Sons Ltd.

Gilbert, Walter, I. & R. Morley Ltd., Heanor, Nottingham. General Manager of Messrs. I. & R. Morley, Ltd.

Settle, James, 257, Church Street, Little Lever, Bolton. Head of Textile Department, Technical College, Radcliffe (City & Guilds Full Tech. Cert. in Cotton Weaving).

Thompson, Leonard, Helmshore House, Helmshore, Lancs. Chief Chemist, Highams Ltd., Accrington (M.Sc. Tech., Member of Society of Dyers and Colourists, British Association of Chemists and Institute of Chemistry).

Wedmore, E. B., The British Electrical and Allied Industries Research Association, 15, Savoy Street, London, W.C.2. Director and Secretary (C.B.E., M.I.E.E., F.Inst.P.).

Old Carpet Hand Looms and Shearing Machines.

Messrs. D. & B. Gladding, Kenbury Works, Kenbury Street, Camberwell, London, S.E.5, have informed the Textile Institute that they have for disposal some hand looms for carpet weaving. Though over 100 years old they are in working order. Each loom occupies approximately a space 5ft. x 5ft. x 5ft. One of these has been sent to the Geffrye Museum.

They have also two shearing machines of the same age, one of which is going to the Science Museum.

The Textile Institute will be pleased to put anyone interested in touch with Messrs. D. & B. Gladding.

- 2. JAN. 1941

THE JOURNAL OF THE
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Vol. XXXI OCTOBER 1940 No. 10

PROCEEDINGS

NOTES AND ANNOUNCEMENTS

Midlands Section

On Saturday, September 21st, the Midlands Section held its first meeting of the session at the Rex Banqueting Hall, Coventry. Mr. W. Pritchard, F.T.I., of Derby, Chairman of the Section, presided, and he was supported by Mr. H. A. Turton, of Messrs. Courtaulds Ltd.

Apologies were received from Mr. Frank Nasmith, who had promised to attend this function but was unfortunately unable to do so on account of ill-health.

Mr. Pritchard, in his opening remarks, said he was very glad to have the honour of officiating at this meeting in Coventry, whose textile industry dated back to the 13th Century.

Mr. H. A. Turton introduced himself as the oldest Textile Institute member in Coventry, and in welcoming the members of the Institute to Coventry he said he was proud that they should have chosen that city for their opening meeting.

In referring to the history of Coventry's textile industry, Mr. Turton pointed out that in 1385 Richard II permitted the Mayor to tax wool and worsted cloth for a period of five years to help pay for the City Wall and Gates. He also mentioned that the ribbon trade had been in existence since the early part of the 18th century.

For some time now there has been under consideration the formation of a local textile society. Mr. Turton emphasised the opportunities that such an organisation would afford in Coventry, and strongly urged that this idea be put into motion. On the proposal of Mr. G. Fielden, of Nuneaton, supported by Mr. H. Biddulph, of Coventry, it was agreed at this meeting to form a Coventry Textile Society. The arrangements for the time being are left in the hands of Mr. L. V. Hewitt, of Messrs. Courtaulds Ltd.

Continuing with the business of the meeting, the subject chosen was "Coventry's Textiles", and Mr. Pritchard introduced the lecturers as follows:—

Mr. L. J. Clarke, B.Com., of Messrs. Wm. Franklin & Son Ltd., who spoke on "Ribbons and Smallwares", Mr. R. I. Martin, A.M.I.E.E., of the British Thomson-Houston Co. Ltd., who gave an address on "Textiles in the Electrical Trade", and Mr. G. Loasby, B.Sc., F.I.C., of British Nylon Spinners Ltd., whose subject was "Synthetic Fibres, Past and Present".

These three lectures were followed with deep interest and stimulated lively discussions.

Dr. E. Wildt, F.T.I., proposed a very warm vote of thanks to the lecturers and was supported in this by Dr. H. C. Smith, of the Coventry Technical College, and the meeting closed with a hearty vote of thanks to the joint chairmen.

RIBBONS AND SMALLWARES*

By L. J. CLARKE, Esq., B.Com.

The lecturer illustrated his remarks by reference to an extensive display of smallwares and ribbons illustrating the many types of work produced in Coventry. The exhibits ranged from ⅜ in. worsted shalloon braid to 9 in. real silk regalia ribbons and many types of jacquard work.

As in other branches of the textile industry, the looms used fall into two main classes, plain and jacquard. Illustrations were given of the decorative effects which could be produced in plain looms such as simple fancy weaves, striped and ombre effects in the warp, and also by the combining of contrasting yarns such as bright and delustred rayon.

The extreme versatility of the smallware loom, while it is to some extent a virtue, tends to prevent the development of specialised looms perfectly adapted for one job. There has always been a tendency to build a loom which could be adapted to a wide range of products.

There is a vast amount of traditional knowledge in this trade based on long experience, but much of it is purely empirical, and has not been submitted to scientific analysis with a view to discovering the underlying principles. There is a very real need for the application of constructive criticism in matters of technique to see whether things which are generally accepted as good are really well founded. This possibility is evident in all traditional trades, especially when they are contrasted with younger industries such as those concerned with rayon, plastics or electricity, which have been developed from their inception on more highly scientific lines.

The complete collapse of the European countries, from which the bulk of the competition in ribbons and smallwares formerly came, has created a very extensive demand both at home and abroad. There are reasons to think that the Continental industry will not speedily re-establish itself after the war. There are also good grounds for assuming that the present time affords a valuable opportunity for British manufacturers of these goods to study methods of production with a view to capturing this trade and by superior technique holding it after the war, even in the face of foreign competition. It may well be that time and money spent in developing methods and machinery may serve to offset the advantages of cheap labour which the Continental industry has for many years enjoyed, owing to the fact that in France and Germany the industry is still to a great extent domestic, and therefore the workers do not need a living wage from their weaving activities, but make up their income from other sources.

TEXTILES IN THE ELECTRICAL INDUSTRY †

By R. I. MARTIN, A.M.I.E.E.

(Research Laboratory, British Thoomsun-Hoston Co. Ltd.)

Textiles form one of the most useful and important groups of materials employed by the electrical manufacturing industry in fairly large quantities, mainly for insulation purposes.

Practically all the principal types of fibres are used. Cotton, silk and asbestos are the more important, but linen, rayon and jute are also used to a smaller extent, and manufactured synthetic fibres, such as glass and nylon, are bein introduced.

The principal reasons for using textiles are their great adaptability an strength combined with flexibility and insulating properties, although the latte are not of a high order and are invariably limited by the presence of moisture. It will be seen that these properties, particularly the mechanical features, combined with the relatively low cost and general availability, are responsible for electrical engineers making such extensive use of textile products.

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* Abstract of a Lecture delivered at Coventry on 21st September, 1940.

† Lecture before the Textile Institute, Midlands Section, at meeting held in Coventry o 21st September, 1940.

In the electrical industry, textile materials are used in the form of yarns, sleevings, tapes and woven cloths. Knitted fabrics are very seldom used and can be neglected.

Textile Fibres. Cotton, Manila hemp, jute and other fibres, either alone or in association with wood-pulp, are employed in the manufacture of papers, pressboard, and vulcanised fibre, which are used extensively for insulating coils, armatures and transformers. Asbestos papers and millboard are made from asbestos fibres which are also employed as fillers in mouldings. Asbestos and cotton fibres are also applied as insulating coatings on wires, a mixture being felted on to the conductor to give a fire-resisting covering. Apart from these few cases the fibres alone are not used to any great extent.

Yarns. Cotton, silk and asbestos yarns are employed extensively for insulating wires, and glass filaments are now being used for the same purpose. The yarns are generally lapped on to the conductors, several ends being applied together; often two or more lappings are applied, in alternate directions, an example being double cotton-covered wire, which is used for winding coils. Silk is advantageous because it takes up less space and is a better electrical insulator than cotton or asbestos.

Yarns are also applied to conductors by braiding, such braided coverings of cotton (usually glazed), silk, rayon, asbestos and jute being applied as a mechanical protection over other insulating materials such as rubber and varnished cloth. The most familiar example is provided by the flexible cords for portable domestic appliances, table-lamps, etc. Asbestos and wool (Genappe) are used where greater resistance to fire is required. In some cases yarns are included as packings between two or more insulated cores, to give additional padding and protection. Jute coverings are applied to heavy cables and are subsequently treated with bitumen and other compounds to give protection against the weather, burying in the ground and other conditions.

Yarns and threads, principally cotton, are useful for tying parts of coils together and for various binding, tying and protective purposes, such as the outer covering of small coils for relays and operating coils of control gear and switchgear.

Sleevings (Tubular braidings). Sleevings of braided cotton, silk and rayon are used for insulating leads of coils, sometimes in the untreated form but more usually after they have been coated several times with a good flexible insulating varnish. The varnished cotton or silk sleevings are familiar to many through their use for slipping over connections of radio sets. Certain high-quality insulating tubings are also made of varnished silk rolled around a mandrel and covered with a varnished sleeving, this combination having superior electrical properties to those of the plain varnished braidings.

Tapes and Webbings. Textiles are most extensively used in the form of tapes and webbings made from cotton, silk or asbestos—the bulk being cotton—for all manner of insulating, binding and protecting purposes. The majority of motor, generator and transformer windings require tapes and webbings for insulating the conductors, binding coils and leads together and wrapping around the exterior to give mechanical protection. They are generally treated with varnishes or compounds (such as bitumen), to give moisture resistance and improve their electrical properties, either during application or by dipping or impregnation after completion of the winding.

Cloths. Fabrics made from cotton, silk and asbestos are principally utilised in three ways: (*a*) Untreated. (*b*) Varnished or compound treated. (*c*) Bonded with synthetic resin.

(*a*) Untreated cotton cloths are employed in various coils and windings; for example, as insulation between layers and as an outer protection against the ingress of dust, oil, etc. Thus, the armatures of tramway and railway motors often have a canvas dust-cap over the end-windings to prevent metallic brake shoe dust entering the winding. These cloths are treated with varnish, shellac or bituminous compound either during or subsequent to the winding operations. Asbestos cloths are used, to a small extent, for similar purposes on machines which have to work at high temperatures.

(*b*) The major proportion of fabrics used is for the manufacture of varnished cloths which is an offshoot of the oil-silk industry. Selected cotton and silk fabrics are prepared with special finishes to give a regular smooth surface, and these are coated on both sides with flexible baking insulating varnishes. Silk fabrics are used where the thinner materials are required, such as 3 to 6 mils (thousandths of an inch), and cotton cloths for the thicker varieties ranging from 5 to 15 mils. In many cases the varnished fabrics are slit into narrow strips or "tapes", such as ¾ inch and 1 inch wide, for insulation between layers and turns of coils, and for taping conductors, particularly parts of motor armatures and field windings. In order to obtain the degree of flexibility required such tapes are usually cut on the bias, the most useful variety being the continuous seamless bias tape. This is made from a tubular woven fabric cut helically to give a continuous sheet, say 36 inches wide, with threads oblique to the edges. The fabric is then starched, calendered and finally varnished in this form, the tape being slit longitudinally so that it, too, has the threads on the bias. These varnished cloths and tapes are most useful and adaptable insulating materials, as the fabric provides good strength and the varnish films on both sides impart good insulating properties. Fig. 1 shows typical coils and bars insulated with these bias-cut tapes.

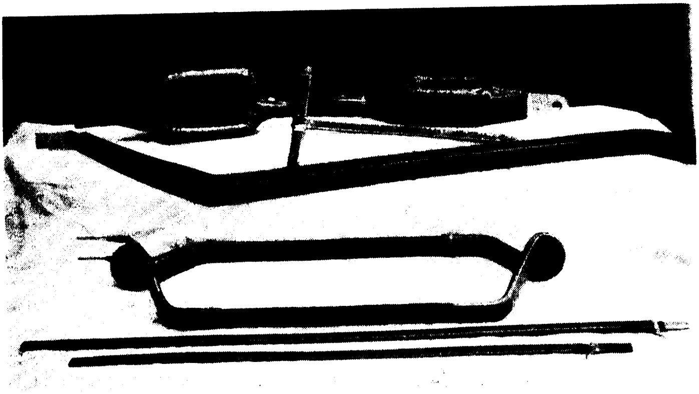

Fig. 1. Typical coils and bars insulated with seamless bias-cut varnished cloth tapes.

Another type of treated fabric used extensively is the material familiar to most wiremen and electricians as adhesive tape, this being a cotton cloth treated with a rubber compound which adheres well on contact.

(*c*) Perhaps the most interesting use of cloths is in the form of reinforcement in boards and mouldings made of synthetic resins. The cloth, usually cotton, is treated with a solution of the synthetic resin (generally of the phenol-formaldehyde type dissolved in methylated spirit) and dried. The coated cloth is then stacked in sheets—for making boards—and placed between polished metal plates in a heated hydraulic press, pressures of about ½ to 1 ton per square inch being applied whilst the temperature is maintained at about 150° C.

During this pressing operation, which may last for periods ranging from a few minutes to two hours depending upon the thickness of material, the resin sets, or "cures", resulting in a solid mass of rigid material having considerable strength. The special sample shown in Fig. 2 was made to illustrate the three stages of this manufacture. The cloth in section (*a*) is untreated, whilst section (*b*) is the cloth after treatment with the synthetic resin (before pressing), and section (*c*) is the final rigid compound board after pressing. This shows clearly the degree to which the material is compressed. Rods, tubes and simple mouldings are also made by pressing the treated fabric in suitable moulds.

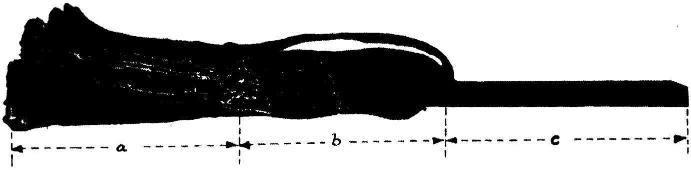

Fig. 2. Synthetic resin bonded fabric compound sample showing stages of manufacture.

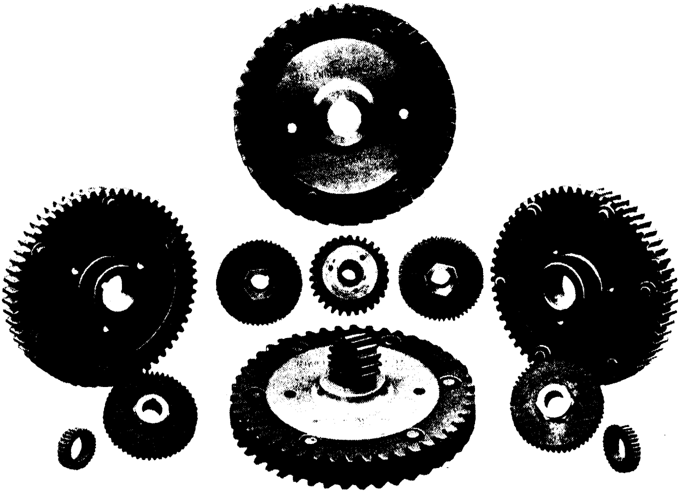

Fig. 3. Gears made from Fabroil-A (Synthetic resin bonded cotton fabric).

Various cloths are used for this purpose ranging from fine cambrics of about 1 oz. per yard to 12 or 15 oz. ducks, according to requirements. For example, the finer cloths are used for thin sheets, suitable for punching into washers and small terminal boards, also for the more intricate mouldings, whilst from the heavy ducks are made thick boards up to 4 inches thick. One of the most important uses of the latter is for making non-metallic gear wheels, such as "Fabroil-A", examples of which are shown in Fig. 3.

The uses of these laminated fabric compounds are numerous, and include moulded spools for coils, insulated bars and operating rods for switches, panels for switchboards, slot wedges for motors and terminal boards for transformers. By the use of a printed cloth for the outer layer a very serviceable diagram board or nameplate is made.

Fabrics cut into small pieces are also used as a filler in mouldings. The small pieces of cloth are impregnated with synthetic resin and mixed with a moulding powder of the Fabrolite or Bakelite type and moulded in the usual way in hot steel moulds.

THE PROPERTIES OF TEXTILES FOR ELECTRICAL PURPOSES

In using textiles for electrical purposes the characteristics and properties which are of greatest importance are usually *not* the electrical ones, it being recognised that the electrical properties are not of a high order and, therefore, as already indicated, the materials are utilised mainly on account of their mechanical and physical characteristics. The chief limiting factors are strength, resistance to heat and moisture, insulation resistance, ageing and chemical properties.

Good tensile strength is usually required with reasonable resistance to wear and chafing (e.g. for cable braidings) and good tearing strength. Fabrics having practically the same strength in warp and weft are generally preferred, particularly for making varnished cloths and laminated compounds. Cotton, especially the Egyptian variety, usually fulfils most of these requirements. Linen is used in a few cases on account of its higher strength.

The effect of heat on all organic insulating materials, particularly textiles and papers, is of paramount importance, since the temperature of operation and, therefore, the rating of the apparatus, are limited by the highest temperature to which it is safe to expose the insulation. In fact, the ratings of motors, generators, transformers, etc., have been decided mainly by the ability of cotton coverings on wires, cotton tapes and varnished cloths to withstand continued heating. As the highest temperature at which it is safe to work any of these materials is taken as about 105° C. and the ratings of the machines, etc., are limited to ensure this is not exceeded. For example, a 10-h.p. motor could be used for 12-h.p. if the temperature could be safely increased by about 10° C. Good grades of cotton and silk are generally satisfactory, it being essential that they do not contain acids or other substances such as chlorides which would accelerate tendering. The asbestos materials are naturally superior in this respect to all the organic textiles, and glass fibre products are also being adopted where practicable for high temperature operation.

The effect of moisture on the electrical properties of textiles is mainly shown by a fall of insulation resistance—a most serious consequence. This is prevented to a large extent by treatment, before or after application, with varnishes, waxes, bitumen and other compounds. The relatively poor electrical properties of the cloth are usually the cause of the laminated fabric compounds having only moderate electric strength and resistance to moisture, but, as will be mentioned later, decided improvements have been made in these respects. The electrical properties of the varnished fabrics and the laminated compounds are, of course, largely determined by the type of varnish or synthetic resin used and the process of manufacture. For example, a bituminous varnish is better than an ordinary linseed oil varnish and certain phenol-formaldehyde resins require longer and more careful curing than others to obtain the optimum electric strength. Nevertheless the fabric itself has its influence, an example being the finish on the surface of cloths used for making varnished fabrics. This has to be smooth and free from nap, otherwise the varnish film is irregular and has low electric strength.

All the textiles used for insulation are required to have good ageing characteristics as, obviously, any deterioration is liable to shorten the life of machines, etc., and may cause failure. The chief cause of failure is the effect of heat, but there are some applications where the effects of corona, sunlight, mildew or micro-organisms cause deterioration.

In addition to their influences on ageing, moisture absorption and electrical properties, chemical constituents and additions may cause other troubles such as corrosion of fine wires in coils, particularly when moisture is present, and on direct current apparatus where electrolytic corrosion is liable to occur. Hence freedom from impurities and chemically active materials, particularly electrolytes, is very desirable.

RESEARCH AND DEVELOPMENTS

Electrical Engineers and Textile Technologists have for many years collaborated in research on textiles to improve their properties and develop new processes and materials. Among the outstanding developments the following may be mentioned as examples.

Washing of Cotton and Asbestos. By careful washing or scouring of cotton yarns, tapes and fabrics, greatly improved insulation resistance has been obtained, combined with less liability to mildew development and corrosion by the thorough removal of electrolytes. This has enabled substantial improvements to be obtained in the electrical properties of laminated compounds, especially under damp conditions of service.

Asbestos tapes have also been improved considerably by similar processes and by the use of specially selected crude fibre.

Acetylated Cotton. The use of acetylated cotton (such as "Cotopa") is being developed actively as this has greatly increased resistance to moisture, heat and chemical effects, and considerably better electrical properties than ordinary cotton. Cotopa fabrics are already being used successfully for making improved synthetic resin laminated compounds in accordance with Patent No. 513,687.

Synthetic Fibres. The advent of completely synthetic organic fibres, such as nylon and vinyon, is opening up a new line of research, and these products are being investigated. The effect of heat on nylon, however, appears to be more severe than is the case with cotton, which is a severe handicap.

Glass Fibre Products. The quest of the ideal textile has inevitably been directed towards one having greater resistance to heat than the organic fibres and better electrical properties under damp conditions than are obtainable with asbestos. Hence the recent introduction of improved spun glass fibre has provided the electrical engineer with a very promising new material, which is obtainable in the form of covered wires, braided sleevings, and woven tapes and cloths.

Many motors have already been completely insulated with glass fibre products and, although a certain amount of organic material in the form of varnish and synthetic resin has had to be used in their construction, they are, nevertheless, capable of being operated at fairly high temperatures such as 200° C. The glass fibres have very high tensile strength but poor shearing strength and are, therefore, liable to damage by cutting and chafing. Also, owing to the smoothness of the yarns, the threads of fabrics readily move apart. Special care has, therefore, to be taken during handling and winding operations, it being usual to pre-treat the tapes and cloths with varnish before use. Although these glass products are expensive they are certainly likely to be utilised more in the future.

CONCLUSION

This brief review of the use of textiles in the electrical industry is necessarily incomplete but should give an indication of the extent to which electrical engineers are dependent upon textile products. There are many technical problems involved which require the closest collaboration between the two industries. This already exists to a marked degree. Very helpful assistance has been given on these problems by such bodies as the Shirley Institute, the Bleachers' Association and the Textile Institute itself, in collaboration with individual firms, the Electrical Research Association and the British Standards Institution.

In conclusion, the author wishes to thank the British Thomson-Houston Co. Ltd. for permission to read this paper and would like to express his appreciation of the opportunity provided by this meeting for acquainting those engaged in textile manufacture with some of the conditions and problems involved in the electrical engineer's endeavours to adapt textiles to his service.

Textile Institute Competitions— Prize Distributions at Leicester and Nottingham

On Monday, 7th October, the prizes won by students in the Leicester district were presented by Mr. P. A. Bentley. The Chairman of the Midlands Section, Mr. W. Pritchard, F.T.I., presided, and he was supported by Dr. E. Wildt, F.T.I., Vice-President of the Institute and past Chairman of the Section.

Mr. Pritchard, in briefly introducing Mr. Bentley, referred to his generosity in providing the prize money for E Competition last year. Mr. Bentley warmly encouraged students to compete. He said that they derived lasting benefits from their efforts out of all proportion to the actual value of any prize. Prizes should be looked upon as tokens.

Dr. E. Wildt proposed a vote of thanks to Mr. Bentley for presenting the prizes.

A similar brief ceremony took place at Nottingham on Thursday, 17th October, at 3-30 p.m.

Yorkshire Section

Textile Institute Competitions—Prize Distribution at Bradford

On Thursday, 3rd October, the Yorkshire Section held its first meeting of the 1940-1941 session at the Midland Hotel, Bradford, when the prizes won by Yorkshire students in the Textile Institute Competitions were presented by Mr. John Crompton, F.T.I. Mr. Crompton was supported by the President, Mr. H. Jaques, A.S.A.A., Mr. George Garnett, F.T.I., and by Mr. Harry Hardy, A.T.I., Chairman of the Yorkshire Section.

Mr. Crompton, in a short address, outlined the foundation and development of the Textile Institute Competitions. He stressed the value to the students of the work they put into the preparation of their albums, whether they were successful in winning prizes or otherwise. He drew attention also to the negotiations in progress, between the Royal Society of Arts and the Textile Institute whereby prize-winners in these Competitions will become eligible to compete for the Society's prizes and Scholarships.

Mr. Garnett proposed a vote of thanks to Mr. Crompton. He referred to the economic difficulties and restrictions arising from the war and remarked on the value of the competitions to those who would be in the struggle for markets after the war.

The vote of thanks was ably seconded by Principal H. Richardson, of the Technical College.

A very pleasing display of the albums and print designs submitted by the prize-winning candidates was arranged by Mr. W. E. King, F.T.I., and Mr. F. E. Ellis, A.R.C.A., A.T.I.

Mr. Kenneth Lockwood gave an interesting display of silent and talking films.

Obituary

Sir William Henderson, C.B., LL.D., D.L., F.T.I.

The Institute has lost, in the passing of Sir William Henderson, another of its Foundation Life Members. Sir William was 77 years of age and had been associated with Messrs. Alex Henderson & Sons Ltd., Jute Spinners and Manufacturers, since 1881. He became a partner in 1892.

Distance prevented Sir William Henderson from pursuing a very active part in the work of the Textile Institute. His energies were devoted to such work as that of the Dundee Chamber of Commerce and the Association of Jute Spinners and Manufacturers. He was once Chairman of the Chamber of Commerce and three times Chairman of the Association.

Sir William was deeply interested in educational and welfare work and took an active part in the building of the Technical College and School of Art. He was Chairman of the College Committee from 1897 to 1936, a governor of University College, Dundee, and a member of the Advisory Committee of the School of Economics and Commerce. In the municipal life of Dundee he was a prominent figure as well as in such movements as the Y.M.C.A. and the Territorial Force. He served as Deputy Lieutenant of the city and a Justice of the Peace.

In 1921 he received the honour of knighthood, having been made a C.B. in 1919. St. Andrew's University bestowed on him the degree of LL.D.

Mr. S. B. Hollings, F.T.I.

Mr. S. B. Hollings died in April at the age of 72. The "Wool Record and Textile World", which he founded in 1909, wrote of him as follows in its issue of April 25th, 1940:—

"The Journal 31 years ago consisted of four quarto pages, but it was gradually built up and developed until in the course of time it won a world-wide circulation, exercising a considerable influence in trade circles at home and abroad. For eighteen years after the Great War Mr. Hollings and Mr. F. H. Meek acted as joint editors, and then in 1936 Mr. Hollings, who for several years had taken a less active interest in journalism, resigned from the staff and went into business on his own account in the wool trade.

"Throughout his life Mr. Hollings took a keen interest in all matters connected with the wool textile industry, but his chief concern was the raw material itself, and more especially the historical side of wool production. He made a hobby of collecting samples of wool from different countries, and was always pleased to lecture on his pet subject. Before the Great War he regularly attended the London wool sales, but although during the last twenty-five years he was seldom seen at Coleman Street Wool Exchange, he never lost interest in the offerings and prices realised.

"At one time he took an active part in the public life at Calverley, his native village, and he was a stalwart of Methodism."

Reviews

"Textile Testing", by J. H. Skinkle (Macmillan & Co. Ltd. Price 15/-).

Mr. Skinkle has done two useful jobs for the English reader. He has described with intimate detail current American practice, and he has sorted and abstracted most of the papers on testing which have appeared in the *Journal of the Textile Institute*. Of 283 references, 91 are to papers in this Journal, and many of the remainder are to other English books and journals. His extracts are so extensive that it would appear that American practice is based on British research. Whether or not this is true, the author has produced a book which covers the wide field of textile testing well.

The book is in three sections, namely, physical, chemical and microscopical testing. The physical section is the largest and discusses a wide variety of special tests, including the measurement of fibre resilience, fabric porosity, thermal properties and draping quality, in addition to more common tests. The chemical section deals briefly with estimations of filling materials, the analysis of mixtures of fibres, tests for damage, and tests for finishing materials including oils, gums and synthetic resins. The microscopical section, being very short, gives brief notes, without illustrations, on the identification of fibres and description of some estimations of quality and damage, including the methods of estimating fibre maturity and extent of mercerisation in cotton, and of measuring the diameter of wool fibres.

The book starts with a chapter on statistical methods. This is an excellent idea, because to the tester the variability of textile materials is their most characteristic feature. The sensitivity required in an instrument should not be decided without reference to the usual variation to be expected in the feature to be measured, and, generally, statistical considerations should help to indicate what refinements are helpful and which are quite beside the point. Unfortunately, the author's first chapter is the poorest in his book, and, perhaps more unfortunately, he fails to show in subsequent chapters that critical attitude which one associates with statistical analysis. His statistical examples are calculated from unsuitable data. The standard deviation as defined for samples consisting of large numbers does not lead to the best measure of variance for small samples, for which the number of degrees of freedom should be used instead of the population number. It seems unfair to the reader to describe how individual differences are found and squared when the mean range method, and the use of an arbitrary origin and arbitrary units are so much more convenient. A general review of statistical method as applied to textile testing would have been an excellent opening. The author has missed his opportunity.

The work of an author on physical testing of textiles is made difficult by the lack of satisfactory books on textile science, which binds him to include more discussion of scientific principles than is necessary in a book on chemical testing, but the author might allow his readers some previous knowledge of arithmetic and so reduce the number of conversion formulae and numerical examples. The formulae quoted, though imposing enough at first sight, are disappointing because they do not, as a rule, add anything to the information already given in words. The book would be improved if most of the formulae and all the examples were printed as notes in very small type.

The illustrations are weak. The diagrams are very rough c.f. Fig. 21 "Regular Twist" which is anything but regular, but they are considerably more informative than the half-tone illustrations. Some of these are recognisable only to persons already familiar with the instruments. Both faults are indications of haste and there is ample corroboration of this in the letterpress: "true accounts" for "true counts", "type" for "T.Y.P.P.", "Ball" for Dr. W. Lawrence Balls, and Figs. 32 and 44 are identical though Fig. 32 cannot be made to fit the detailed description. There are indications, too, that the author has not first hand experience of some of the tests he describes. For instance, has he tried drawing a chalk line on a velvet pad and then making a Baer diagram on it, as he recommends? There are some other ideas mentioned which should not have been left unsupported. Some of these are, that cotton stapling gives the average fibre length, that "yarn might be very uniform as regards counts, but the twist might be very uneven", that belting duck should have minimum crimp in the warp, and that "clothing seldom wears out".

His "references" at the end of each chapter, though numbered, have no corresponding numbers in the type and the page of the reference is not indicated. They are, in fact, mere bibliography and might with advantage be collected and put at the end of the book. It is an unfortunate result of his sections that the immaturity test for cotton is separated from the Baer diagram and hair weight per centimetre test by 200 pages, but the author might have sustained the reader with a reference.

So long as our subject continues rapidly to expand and become more complex, the author's job will be difficult ~~and~~ no doubt it will always be much easier to review the book than to improve on it. Our thanks are due to Mr. Skinkle but, next time, could he publish the second edition first? A. W. Bayes

Davisons' Textile Blue Book (United States, Canada and Mexico). Diamond Jubilee Issue, July, 1940. (Office Edn. $7.50, Handy Edn. $5, Salesmen's Directory $4.—Foreign Countries 50 cents extra).

The compilers of this valuable directory are to be congratulated upon this issue.

The work must be absolutely indispensable to those engaged in textiles in North and Central America for the arrangement of the Directory is excellent. Davison Publishing Company have nothing to learn about their job.

List of Members and Records

The Textile Institute "List of Members and Records", which is normally published annually, was last issued in May, 1938. Many changes of address have been notified, particularly since the outbreak of war.

The Finance and General Purposes Committee consider that no good purpose would be served by correcting and reprinting at the present time. Instructions were given for the preparation of corrected typewritten copies, one of which will be available to members at the Institute. Inquiries sent to the Institute regarding members' addresses will be answered by return of post.

Office and Library Hours

The Finance and General Purposes Committee has agreed temporarily to alter the office hours so that the members of the clerical staff may get to their homes reasonably early in the evening.

Notice is therefore given that the Institute Library will close at 4 p.m. from the present date to the end of February, 1941. The Office will be open from 9 a.m. to 4-30 p.m.

Textile Institute Diplomas

Elections to Fellowship and Associateship have been completed as follows since the appearance of the previous list (September issue of the *Journal*):—

FELLOWSHIP

JAMES RUSSELL HEALEY,
Lecturer, Bradford Technical College.

ROWLAND STYANT MEREDITH,
Manager and Director. Messrs. Adam & Lane & Neeve Ltd., London.

ASSOCIATESHIP

PHILIP BROUGHTON LAW.
JOHN EDWARD LYNAM.

NOTICES: INSTITUTE MEETINGS

Tuesday,	5th November	*Manchester*—1.15 p.m. Meeting of the Diplomas Committee at the Institute.
Tuesday,	5th November	*Manchester*—2.45 p.m. Meeting of the Publications Committee at the Institute.
Wednesday,	20th November	*Manchester*—2.0 p.m. Meeting of the Finance Committee at the Institute.
Wednesday,	20th November	*Manchester*—2.45 p.m. Meeting of the Council at the Institute.

OTHER ORGANISATIONS

Blackburn Textile Society.

Friday,	8th November	*Blackburn*—Lecture: "Shrinkage in Cotton Goods" by G. E. Collins, M.Sc.Tech. (Shirley Institute, Manchester).
Saturday,	16th November	*Blackburn*—Visit to Richmond Hill Paper Works.
Friday	22nd November	*Blackburn*—Lecture: "Sizing Ingredients: Their Use and Abuse" by W. W. Wilkinson, A.T.I. (Technical College).

Bradford Textile Society.

Monday,	4th November	*Bradford*—Lecture: "Olive Oil Substitutes" by Dr. L. L. Lloyd, Ph.D., F.I.C. (Bradford Technical College), at the Midland Hotel, at 7.0 p.m.
Monday,	18th November	*Bradford*—Debate with Batley, Dewsbury, and Morley Textile Societies on "Woollen and Worsted Cloths" at the Midland Hotel, at 7.0 p.m.

Morley and District Textile Society.

Monday	18th November	*Bradford*—Joint Debate with Bradford Textile Society at the Midland Hotel, at 7.0 p.m.

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TEXTILE INSTITUTE

Vol. XXXI NOVEMBER 1940 No. 11

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PROCEEDINGS

NOTES AND ANNOUNCEMENTS

Lancashire Section

Institute Competitions Prize Distribution at Burnley

The Lancashire Section met on Saturday, 26th October, 1940, at the Burnley Municipal College, when the prizes won by Lancashire students in the Institute Competitions were presented by Mr. H. Haygarth Jackson, Executive Officer of the Cotton Board. The Chair was taken by Mr. J. Crompton who said he was always very pleased to take part in any function connected with the Institute Competitions. He observed that he had been in contact with the Burnley Municipal College for nearly 50 years. He was glad that the suggestion that the Institute Competitions should be suspended because of the war had not been acted upon, because although many young men were being called to the Colours he thought it necessary that Textile Institute activities should be kept going as far as possible. He referred to the disinclination of young people to enter the textile industries, preferring office work to industrial craftsmanship. He thought, however, that the Competitions such as those conducted by the Textile Institute did stimulate the young designers and so serve a useful purpose in bringing young people into the industry.

Dr. F. Briers, Principal of the Burnley Municipal College, said that to him fell the very pleasant duty of extending a welcome to Mr. Crompton, Mr. Haygarth Jackson, and the Textile Institute. The war was responsible for the discontinuance of the annual meetings in Manchester at which the prizes won throughout the country were presented. Burnley, however, was particularly pleased to have this prize distribution at the Municipal College because students from the Textile Department in the College had won the most valuable prize in the Competitions for the last three years. Dr. Briers said he could not claim an intimate knowledge of the textile industry but he paid a tribute to the Textile Department of the College and the Art Section in the matter of their success.

Mr. J. Crompton then called upon Mr. Haygarth Jackson to distribute the prizes, a full list of the winners of which appeared in the August issue of the Institute *Journal*.

Mr. Haygarth Jackson addressed the meeting and said, " It is a great pleasure to be invited to speak at this gathering today because it recalls some pleasant years before the last war when I was doing work with designs similar to what you have on exhibition today. I was very keenly interested in textile designing and for the last twenty years or more have been responsible for many hundreds of designs which are now being used all over West, East and South Africa. Yesterday I spent some time examining the work done by students and, apart from being impressed with the quality, ingenuity and novelty, I had some feelings of relief that I had not been asked to adjudicate. It must have been extremely difficult to arrange the order of merit for such a display of talent and the gentlemen who took on the job have my sympathy. There is strong evidence of ability coming along for the future production of our textiles and this will enable us to hold our place in the front rank of the world's textile manufacturers.

"The urge to create something beautiful, expressive or useful is found in practically all races, even in the wild, untutored savage, and there is evidence in almost every corner of the world that for thousands of years, man has been producing beautiful things. Man somehow must design ; he has always been designing, and he simply cannot refrain from designing. I remember three or four years ago going into a natural cave in the wilds of Southern Rhodesia where I saw all sorts of weird carvings on the stone sides. Admittedly they were only crude representations of animals and other objects and scientists have no idea when they were done. They were definitely not African in origin, and one wonders what sorts of tools were used. I remember seeing beautiful designs carved in the ancient tombs of Egypt and the world was startled and impressed by the priceless works of art recently brought to light from Tutankhamen's tomb, where they had rested for three or four thousand years. I have seen in Central Africa crude, though extremely interesting, works of art, done by the African natives, crude ideas, but with definite artistic talent and always expressive of something in the native's religion, surroundings and superstitions. The denizens of North Africa have a distinct art of their own, sometimes beautifully carried out by designs tooled and embossed on leather and used as saddles, divans and even clothing. We are all aware of the inspired art of the carpet industry of Persia, where designs handed down through generations are perpetuated by families or villages or tribes. The colours in their designs change very little and experts can tell in what district or by what tribe they are produced. There is perhaps nothing strange in man's desire to give expression to his artistic urge when he is surrounded by innumerable natural examples of beauty and design. What inspiration there is for the artist in the colour, tones and transparent beauty of a butterfly's wings, the gay plumage of a bird, the colours of a brilliant sunset, the beauty and symmetry of a well-grown tree, or plant, or flower! How seldom does nature misuse her colours or lines, or create anything not in harmony! Is it any wonder that we all want to draw?

"In wandering round the world for the last 25 years, I have often tried to assess the culture of a country from the art it displays, from its buildings, its designs, its furniture, its clothes. The French are perhaps the most generally artistic nation in the world, but I sometimes wonder, whether, as far as textile designs are concerned, they have not been given too high a place. In Germany their art appeared to me heavy, gross, coarse and crude, perhaps befitting to their nature, and this despite their much vaunted 'kultur.' In general, the art of America is practical and essentially modern, and they draw to themselves what they consider the best art of all countries. In England, so steeped in tradition, the underlying note is generally quality and, at least to our minds, good taste. What a crime it is that so many countries should now be concentrating their efforts on the destruction of artistic things which generations of craftsmen have handed down to us. Lancashire was the pioneer of the cotton industry. For years we produced the bulk of the world's cotton goods and had the world's markets at our feet. We taught other countries how to make cloths and how to decorate them by the cunning use of coloured threads, by means of dyes, by printing in tens of thousands of designs, and by dobby and jacquard effects woven into the cloth. Lancashire had reason to be proud of her achievements and should be proud today that she can still lead the world in this field. It is a strange characteristic of the British that they should be inclined to depreciate anything they have produced and attach exaggerated value to things made abroad. A Paris frock to the Englishwoman is the last word. Perhaps on the other hand, there is a certain glamour attached to something produced in another country and imported to this. I feel, however, that we have for too long been depreciating the value of our own goods. Other nations, generally speaking, have not got ahead of us. Just as we have taught the world the art of producing cotton goods, so we must aim at leading the world in quality and design. Never have we had a better opportunity than today. France of late years has been considered by the world to be the centre for design, fashion and style, but she can no longer hold this position. I would like to see Britain acquire this reputation and, for cotton goods, re-establish it in Manchester. We want Manchester or Lancashire to be the fashion centre of the world. One of the many ways in which the Cotton Board is planning to recover export trade is by establishing a Colour, Design and Style Centre in Manchester, and details of this project appeared in the press last week. It has been under consideration for some time. What will be the object of this centre? It will be to arrange exhibitions of fabrics, garments and fashions as they are produced ; to encourage the development of design, creation of new fabrics and to have a central library and depot, where all design and fashion developments can be examined, discussed and put to the best use of the trade in general. It is proposed also to have a library for all foreign developments in this particular field, from which we can learn of the progress foreigners are making in style, colour and new fabrics. Mr. Cleveland Belle has been appointed Administrator of this new Centre and I am going to ask him to make a point of inspecting your wonderful work and selecting, if possible, some design or fabric which could be immediately used. He may find hidden talent and launch it into industry.

"Before I joined the Cotton Board, one of my great interests was the production of African designs. For this I derived inspiration from all sorts of objects, carpets, wallpapers, things in shop-windows, ladies' frocks, even embossed silver paper, and so on. I think one of the greatest thrills I ever had was once in the Belgian Congo. I remember looking into the street from the verandah and seeing designs on cotton prints, which I had produced a few months before, being worn by dusky ladies passing by me in the direction of the native market. I hurried through my breakfast, borrowed a friend's car and toured the district to see many more of my designs in actual use.

The work of the Cotton Board is primarily to develop exports. We are well aware that design and colour will play an enormous part. The first sense which is reacted upon is that of sight. A beautiful design, print or fabric is half sold if the appeal to the eye is effective, and provided the finish, handle and price are right, the goods will sell readily. We shall look to you, our coming producers and designers, in the next few years to help us tell the world to 'Buy from England if you want the finest textiles the world can offer.' "

The Chairman called upon Mr. J. W. Pennington, Head of the Textile Department of the College, who referred to the success of Burnley students in the Institute Competitions in which he was pleased to say they had figured since 1918. He paid tribute to the excellent co-operation of the Art Department and thought that the extension of the Institute Competitions to the woollen and worsted industries was a move in the right direction. Finally he expressed his appreciation of the encouragement of the Burnley Education Committee in the work of the College.

The meeting closed with votes of thanks to Mr. H. Haygarth Jackson and to the Chairman for presiding.

Yorkshire Section

On Thursday, 17th October, 1940, the Yorkshire Section met at the Midland Hotel, Bradford, when a paper on "The Public Health (Drainage of Trade Premises) Act, 1937," was read on behalf of Mr. J. H. Garner, B.Sc., A.I.C., Chief Inspector, West Riding of Yorkshire Rivers Board, who was absent through ill-health. The Chairman of the Yorkshire Section of the Institute presided. The weather and the black-out were probably responsible for the small attendance.

The discussion which followed was of unusual interest. It was not confined to the treatment of effluents from textile works, though these received special attention.

Correspondence

To the Editor, "Journal of the Textile Institute."

Dear Sir,

As Secretary of the Textile Teachers' Association, Lancashire Branch, I wish to deny the report which appeared in the daily press, that an address was given to our Association at its meeting in Blackburn on the 26th October, 1940, by Mr. F. Mercer, forecasting the time when cloth would be produced without looms.

Far from giving an address to our Association, Mr. Mercer was not even present, and the matter was neither mentioned nor discussed at this or any other meeting of the Association.

I should be greatly obliged if you could find space to publish this denial in the *Journal.*

Yours faithfully,
HERBERT FULLARD, *Hon. Secretary,*
Textile Teachers' Association, Lancashire Section.

12th November, 1940.

Reviews

The Rarer Wools. By E. S. Harrison. Published by James Johnston & Co., Elgin, 1940.

A short account is given of the sources of supply, characteristics and uses of hair from the camel, alpaca, llama, vicuna, guanaco and paco-vicuna, and of mohair, cashmere, Angora rabbit wool and musk-ox hair. The facts are stressed that all these rarer wools are blends of coarse and fine fibres and that the necessary processing to remove the former accounts for the comparative costliness of articles made from them. The booklet is well printed, and illustrated with attractive woodcuts. W.

Toxic Gases in Industry. The Detection of Organic Halide Compounds.

[With the issue of No. 12—Organic Halogen Compounds (H.M. Stationery Office, price 2d.)—the Department of Scientific and Industrial Research completes its series of leaflets on methods for the detection of toxic gases in industry.]

The wide use of organic halogen compounds as solvents and cleaning agents makes the occurrence of dangerous concentrations of the vapours possible in such industries as artificial silk, bleaching and dyeing, dry cleaning, electroplating, engineering, lithography, rubber, etc. Ten of the commonest organic halogen compounds are dealt with, and the symptoms due to exposure to the vapours described. The effects are mainly narcotic, but tetrachloroethane, for example, is highly injurious to the liver.

The method of detection described is by the use of a form of blow lamp called the "Halide Detector Lamp" which burns pure alcohol in a supply of the air under test. The organic halide is decomposed, the corresponding copper halide is formed on a small copper screw in the nozzle of the lamp and, depending on the nature of the organic halide, the degree of green colouration in the flame indicates the concentration present. A table is given linking the appearance of the flame with concentrations of each of the ten halides. The exact procedure to be followed in using the lamp is described in the latter part of the leaflet. It must not be taken into an atmosphere containing inflammable vapours, and a special method of test is outlined for use when inflammable vapours are present.

Manual of the Textile Industry of Canada. 12th Edition. Montreal: Canadian Textile Journal Publishing Co. Ltd., 1940.

This annual publication contains information on the economic and technical aspects of Canada's textile industry. There are also included a directory of Canada's 509 textile mills (the largest number of these—184—being producers of knit goods) arranged according to provinces, an alphabetical list of textile mills and a buyer's classified index. The economic section deals with markets, employment, plant modernization and the rayon and tailoring industries. Statistics are given of primary and secondary textile industries, imports and exports of textiles, imports of raw materials, and textile output for 1938. Primary textile manufacturing leads all other industries in the number of persons employed and salaries and wages paid, being exceeded (in 1937) in gross and net value of products only by pulp and paper, and non-ferrous metal smelting and refining. There are articles on the textile industry in Canada's war economy and on the wool industry, with special reference to the clothing of the Canadian Active Service Forces. Technical features discussed are developments in plant modernization, humidification and air conditioning, mill lighting, and cotton and rayon finishing plant. W.

British Cotton and Rayon Textiles. Issued for the Information of Buyers of Cotton and Rayon Textiles and Textile Products. (Designed and Published for the Cotton Board, Manchester, England, by the National Trade Press Ltd., London.)

This magnificently produced work consists of five sections following a foreword by Sir Andrew Duncan, President of the Board of Trade. The purpose of the volume is tersely stated in Sir Andrew's second paragraph:—

> "Behind the cotton and rayon export trade of this country lies the skill and determination of 400,000 operatives and 4,000 firms, the co-ordinating energy of the Cotton Board and the vigilant care of His Majesty's Government. The British cotton and rayon industry is proud of its overseas customers and representatives, and it values the confidence which they place in its products. The message of this book is that these products are still available in splendid variety, and that the opportunities of profitable use of British textiles continue in war time as in peace."

Section I is devoted to woven and printed piece goods including dress fabrics, shirtings, linings, lingerie and shower-proofed fabrics. Section 2 deals with the textiles in wear and shows in very brief but strikingly illustrated articles that there are no textile requirements which cannot be adequately met by British products. Furnishing fabrics of all types are treated in Section 3 in which the illustrations have been chosen with outstanding success. In Section 4 domestic textiles are featured. That such a remarkable display to illustrate the use of textiles in the bed-room and the dining-room has been achieved proves that the compilers of this book have done an extremely fine piece of work. The last section is given to miscellaneous articles of which, naturally, only a small number can be discussed and illustrated.

Remembering the functions of the Cotton Board, one assumes that among the more important objects of this publication is the stimulation of orders from abroad. The work has been so very well done that one is left with the feeling that everyone in this country, into whose hands the book comes, will want to keep it. No praise is too high for it. The designers, the compilers and the printers are to be heartily congratulated.

Animal Fibres of Industrial Importance: Their Origin and Identification. A. B. Wildman. (Published, in conjunction with the International Wool Publicity and Research Secretariat, by the Wool Industries Research Association, at Torridon, Headingley, Leeds, 1940.) Pp. 28, 5 figs., xxiii plates.

This little book is a good example of the sort of monograph that has been so often needed but lacking in the English literature of the science of textiles. In a little space the author gives much information and many good photomicrographs of the minor hair fibres.

The introduction explains that the microscope, generally a valuable aid to identifying fibres, is here essential. However, no one test suffices; all the evidence, the shapes and sizes of the fibres, their medullation and pigmentation, and the appearance of the scales must be weighed together. It is therefore appropriate and useful that the author gives the essential technique to obtain this evidence. That the descriptions are clear to an experienced microscopist cannot be questioned, but it is doubtful if they would be to one less experienced. There are many places where for economy of text the details have been only hinted at, for example, when discussing mountants on p. 9 and methods of illumination on p. 10. Again the method of using the Hardy section cutting device referred to on p. 7 might well have been described fully, for this is a tricky little instrument and the American reference is not easily accessible in this country.

The main part of the booklet is the series of sections on the different fibres—alpaca, llama, vicuña, camel, mohair, cow, calf, cashmere, musk ox and bison. Each section contains a critical account of those characteristics which taken together enable the fibres to be identified. With this information and some practice it should be possible to identify any of these fibres, and to this end the 60 photomicrographs should help. A minor criticism of these is that the types used in the legend under each could have been selected so that the name of the fibres would have been more prominent than that of the units of the attached scale. Unfortunately it was not, and the word MICRONS, repeated so many times in such heavy type, is pointlessly obtrusive.

The booklet begins with a map of the world showing the origins of the different fibres and ends with a glossary and a collection of references. A copy should be obtained by anyone interested in the subject matter of its title.

J. M. PRESTON.

Physics and Windows in War-time.

War inevitably causes much nonsense to be written on many topics, and in this respect, the problem of protecting windows from blast ranks high in the list of subjects so treated. In few branches of scientific research are more freak results encountered than in explosives. It is practically impossible to predict results and the physicist finds himself reluctantly forced to adopt the practice, so much commoner in research work of some other types, of rejecting results which depart considerably from the average. The unsightly plastering of windows with imperfectly adhering strips of paper has, presumably, arisen from the unwarrantable generalisations from imperfect observations by untrained or only partially trained "authorities."

Dr. Moore's article in the October, 1940, number of the *Journal of Scientific Instruments* is very timely. It might have saved useful material and much valuable time and effort if it had appeared earlier and been given publicity worthy of its value. To the physicist, at any rate, it causes reaction like that experienced by the normal healthy person on getting into clean fresh air after being confined for hours in a stuffy vitiated atmosphere.

The domestic problem can and should be kept separate from the industrial one on account of its greater simplicity. For glass blown out, little can or need be done. The main precautions to be taken by the householder are to prevent the effects of flying glass splinters on people and foodstuffs. Substantial curtains, preferably at some distance from the window, are probably for this purpose as good as, if not better than, anything else.

The industrial problem, being so much more complicated, is correspondingly more interesting. In this connection the work carried out at the Building Research Station of the Department of Scientific and Industrial Research and in other laboratories is of special importance. Some of the results of the investigations have been incorporated in British Standard Specifications (A.R.P. Series) and Dr. Moore's article refers readers to A.R.P. Memorandum No. 12 "Protection of Windows in Commercial and Industrial Buildings" (H.M. Stationery Office) and Bulletins issued by the Research and Experimental Department of the Ministry of Home Security.

When the problem combines the demands of protection from blast with light obscuration it presents greater difficulties. To those unread in physics the cracking of glass, in windows and roof lights exposed to strong sunlight, painted black to comply with black-out regulations, must have appeared mysterious. It is interesting to note that cracking is due rather to temperature differences between different parts of the sheet than to the temperature gradient through it. Constraint at the edges also exercises a strong influence on the results.

Dr. Moore's discussion of the problems can be very strongly recommended to all who have to deal with this subject in industrial buildings. Consideration of the recommendations will save time, money and disappointment.

General Items

New Members

Applications for membership have been received from the following :—

Ordinary.

ALLEN, T. G., 64, Daventry Road, Cheylesmore, Coventry (Chemist, Courtaulds Ltd., Coventry).

COURTS, Ernest Walter, " Oakleigh," 11, Humphrey Burton's Road, Coventry (Works Chemist, Messrs. Courtaulds Ltd., Coventry).

DOWNEY, E. C., 9, Derwent Drive, Brooklands, Manchester (Textile Production Officer, Ministry of Aircraft Production).

EISIG, Gerhard W., Dalton Hall, Victoria Park, Manchester, 14 (Research Chemist, Bleachers Association).

FILDERMAN, G., 20, Cromer Terrace, Leeds, 2 (Student).

HERCHES, Dr. H. H., Romarez 5, Norrkoping, Sweden (Consulting Specialist in Organisation and Management of Textile Mills).

KNOWLES, Charlie, 125, Prince of Wales Road, Coventry (Factory Manager, Courtaulds Ltd.).

LINN, R. J. S., 23, Knights Crescent, Tettenhall, Staffs. (Dyehouse Manager, Courtaulds Ltd., Wolverhampton).

LOASBY, G., B.Sc., F.I.C., 16, Baginton Road, Coventry (Works Manager).

McMEEKIN, W. S., 51, Kirkliston Park, Belfast (Assistant and General Works Manager, Belfast Ropework Co., Ltd.).

SMITH, J. D., 37, Charleston Drive, Dundee, Angus (Flax Mill Manager).

STYAN, George Eric, B.Sc. (Lond.), Messrs John Smith & Sons Ltd., Fieldhead Mills, Preston Street, Bradford. (Analytical and Research Chemist).

WALLACE, William, 8, Laburnum Grove, Cross Roads, Keighley (Instructor, Weaving Dept., Keighley Technical College).

WILSON, G. E., B.Sc., F.C.S., 16, Gloucester Avenue, Lenton, Notts. (Manager Crepe Sizes Ltd., Nottingham).

Junior.

BATEMAN, Albert., 52, Glenroyd Terrace, Cleckheaton Road, Odsal, Bradford (Analytical Chemist and Technical Textile Dyer).

BURBRIDGE, S. A., 44, Barlock Road, Basford, Nottingham (Dyestuffs, Testing, Matching, Dyeing and General Laboratory Work).

FARRINGTON, S. W., c/o Mrs. Wood, 25, Merchant Avenue, Spondon, Derby (Shift Chemist, British Celanese Ltd.).

FOSTER, R., 65, Aston Road, Bramley, Leeds (Textile Research Assistant).

HAY, James Austin, " Laurelville," Roddens, Larne, Co. Antrim (Apprentice Manager).

HORSFALL, Walter, 107, Middleton Road, Morley, Leeds (Technical Assistant, Wool Industries Research Association).

KADER, M., 42, Clarendon Street, Nottingham (Student).

MULHOLLAND, D. B., 61, Cliftonpark Avenue, Belfast, N. Ireland (Research Student, L.I.R.A.).

NOTICES: INSTITUTE MEETINGS

Tuesday,	3rd December	*Manchester*—1.30 p.m. Meeting of Publications Committee at the Institute.
Tuesday,	3rd December	*Manchester*—2.45 p.m. Meeting of Diplomas Committee at the Institute.
Wednesday,	18th December	*Manchester*—1.45 p.m. Meeting of the Finance and General Purposes Committee at the Institute.
Wednesday,	18th December	*Manchester*—2.45 p.m. Meeting of Council at the Institute.

LANCASHIRE SECTION

Thursday,	12th December	*Oldham*—6.0 p.m. Lecture: "Shortage, Selection and Training of Textile Operatives," by H. Rostron, Esq., at Oldham Municipal Technical College. The Chair will be taken by B. Shore, Esq., Chairman of the Oldham Technical Association.

YORKSHIRE SECTION

Thursday,	12th December	*Bradford*—7.0 p.m. Lecture: "Excess Profits Tax," by V. Walton, Esq., F.C.A. (Messrs. Victor Walton & Co.), at the Midland Hotel. The chair will be taken by H. Hardy, Esq., A.T.I.

OTHER ORGANISATIONS

Blackburn Textile Society.

Friday,	6th December	*Blackburn*—Lecture: "The Weaving of Furnishings and Hangings," by A. S. Sanders, Esq., Preston.
Saturday,	14th December	*Blackburn*—Visit to Works of Messrs. Walker, Jacquard Makers and Harness Builders, Weir Street, Blackburn.
Friday,	20th December	*Blackburn*—Lecture: "The Economic and Efficient Maintenance of Jacquards," by A. Sumner, Esq., Bury.

Bradford Textile Society.

Monday,	2nd December	*Bradford*—7.0 p.m. Lecture: "Export—and Live," by D. Hamilton, Esq. (Messrs. D. Hamilton & Co. Ltd., Bradford), at the Midland Hotel.
Monday,	16th December	*Bradford*—7.0 p.m. Lecture: "The Weaving of Fancy Cloths," by W. W. Marland, Esq. (Messrs. W. & A. Riley Ltd., Colne), at the Midland Hotel.

British Association of Managers of Textile Works.

Saturday,	14th December	*Manchester*—6.0 p.m. Lecture: "Current Cotton Trade Problems," at the Victoria Hotel, Manchester. (Lecturer's name to be announced later.)

Coventry Textile Society.

Saturday,	7th December	*Coventry*—2.30 p.m. Lecture: "Personality—A man and his work," by G. E. Wilson, Esq., B.Sc., of Nottingham, at the Coventry Technical College. The Chair will be taken by Mr. H. A. Turton.

1. APR. 1941

THE JOURNAL OF THE TEXTILE INSTITUTE

Vol. XXXI DECEMBER 1940 No. 12

PROCEEDINGS

NOTES AND ANNOUNCEMENTS

THE PUBLIC HEALTH (Drainage of Trade Premises) ACT, 1937

In March, 1940, a paper on the Public Health (Drainage of Trade Premises) Act, 1937, was read by Mr. J. H. Garner, B.Sc., F.I.C., M.I.Chem.E., Chief Inspector of the West Riding of Yorkshire Rivers Board, to a joint meeting of the Yorkshire Section of the Society of Chemical Industry and the North-Eastern Branch of the Institute of Sewage Purification at Leeds. Mr. Garner pointed out that the Act is the first piece of public legislation designed to promote the purification of rivers that has been passed by Parliament since 1876, and that it will entail far-reaching changes in old-established principles of sewage law and practice. He traced the historical developments leading to the Act, briefly reviewed its general aims and objects, and gave an instructive account of the provisions of the Act in relation to rivers pollution prevention authorities, local sanitary authorities, and manufacturers. A report of his address will be found in *Chemistry and Industry*, 1940, Vol. 59, pages 339-343.

The suggestion was made at the meeting in Leeds, that it would be helpful if the Act could be discussed from the point of view of textile manufacturers. Consequently, the paper was presented to the Yorkshire Section of the Textile Institute at a meeting held at the Midland Hotel, Bradford, on the 17th October. Unfortunately, Mr. Garner could not attend owing to indisposition, but Dr. H. H. Goldthorpe (Manager and Chemist, Huddersfield Sewage Works), deputised for him.

Mr. Harry Hardy, Chairman of the Yorkshire Section of the Textile Institute, presided over the meeting, to which members of the North-Eastern Branch of the Institute of Sewage Purification had also been invited.

Before calling upon Dr. Goldthorpe to read the paper, the Chairman paid a tribute to Mr. Garner's work in connection with the work of the West Riding Rivers Board. The Rivers Board was always willing and anxious to give advice and help to manufacturers and the textile community in general did not always realise the help that was available, simply for the asking.

Dr. Goldthorpe said that just previous to coming to the meeting he had opened Ruskin's "The Crown of Wild Olive," in which was a preface relating to the beauty of the Wandle Valley before man marred the scene. By merely changing the names of the villages, pools and streams, this chapter could be applied to many of the once beautiful valleys and glens in the West Riding. Dr. Goldthorpe hoped that by the co-operation of manufacturer, local official and Rivers Board personnel in the application of the 1937 Act, it might be possible to return to some measure of the former beauty in and along the rivers and streams.

At the meeting in March, he had made the suggestion that a paragraph might have been included in the Act in relation to sewage works managers, for it was on those unfortunate people that much of the burden would fall.

As the members would be aware, it was impossible to remove such soluble salts as those of sodium, potassium and, to a lesser degree, calcium, in the various processes of sewage purification. In the later stages, much of the work of purification was carried out by biological means, e.g. percolating filters or activated sludge processes. Just as the roots of a growing plant required a balance between certain salts in solution in the moisture of the soil, so did the various micro-organisms in sewage purification processes. He thought some trade waste problems might be solved by attention to this point.

There was a case in the Ruhr Valley in Germany which might be worth mentioning. The river flowed down the valley through several towns, and water was taken for drinking purposes by one town and discharged as sewage ; the next town, especially in times of drought, treated this water for drinking purposes and again passed it out as sewage, and so on. One chemist was so interested that he decided to test how many times he could purify sewage by such repeated transformations, and he repeated the purification eleven times. The water produced each time was perfectly safe for drinking purposes, but after the eleventh purification it was so salty as to be objectionable.

Mr. Hardy, opening the discussion, said it was evident from the different factors involved in this very important Act that they had to use their imaginative insight. Co-operation was stressed, and rightly so. It reminded him of an example of a certain manufacturer who was very upset when he started discharging his effluent to the Corporation sewers on being called upon to pay £600 a year for the privilege. Previously he had treated the effluent himself. Actually, however, he effected a saving of considerably more than £600 a year, because he found he had been wasting water, at 1s. 0d. per thousand gallons. The sewage works manager got in touch with the manufacturer and pointed out that his methods of wet processing were out of date.

In textile processing one found examples of downright wastefulness in the use of water. When water was wasted the volume of effluent discharged to the sewers was increased and the treatment charges were higher. It was a point which should receive the close attention of manufacturers. The woollen section of the textile industry, as distinct from the worsted section, was perhaps more deeply concerned in this particular question of cost of water and effluent charges.

Reference was made in the paper to the right of manufacturers to continue treating their effluents themselves, if they wished to do so. Take the woollen manufacturer with his small plant, in which he attempted, by precipitating the fatty acids, to recover oil from the effluent, in the form of magma, which, after pressing, became sud cake. He lost the benefit of the averaging tanks, sedimentation tanks, filters and humus tanks, which the sewage works engineer had at his disposal. The manufacturer who attempted to turn out an effluent with the idea of satisfying the very exacting conditions laid down by the West Riding Rivers Board would find that, as a rule, ideals were seldom reached in practice. It was a very difficult task when one manufacturer could discharge his effluent to the sewer without charge, while another had to pay, say 4d. per thousand gallons. It seemed to him that the textile industry, and particularly the Yorkshire Section of the Textile Institute, might put forward a recommendation that trade effluent charges should be more or less uniform in all parts of the West Riding. Some manufacturers were very worried about this problem. It was serious and had considerable effect on the balance sheet, particularly in times when competition was so severe as in the years 1921-22 and 1930-31, and the other so-called slump years. If uniform rates could be established, so that manufacturers in different parts of the West Riding would be on a similar basis, it would result in conditions which might be described as reasonable and fair to all the manufacturers concerned.

He would be very pleased if Dr. Goldthorpe would give them his opinion on this variability of charges which operated throughout the West Riding. Did he think it a reasonable suggestion to make, in the interests of the woollen industry of the West Riding, that charges might in the near future be the same in all parts of the Riding?

Dr. Goldthorpe agreed with Mr. Hardy that there was great variability in the charges for the treatment of trade wastes by the local authorities in the West Riding. Some authorities regarded the treatment of trade waste just as part of the local authority's services and made no charge. Others differentiated between the manufacturer who had no trade waste and the one who had, and required the trade waste treatment to be paid for as something extra to the rates. The introduction of trade waste to the sewers meant an enlargement of the sewage works. Such extensions were costly, and he thought the trader, in all fairness, should be asked to contribute to this extra cost. The manner of assessing this cost varied, too. Some manufacturers were charged on their water consumption, others had their effluents metered, and some agreed to pay a fixed sum per annum predetermined by a mutual arrangement between manufacturer and local authority's representatives. Such methods of charging for trade effluents took little account of their strength and nature. He thought the rate of charge suggested by the Engineer of the West Middlesex Main Drainage Works was a fair means of assessing a trader's liability. This was arrived at from the following formula:—

> Charge in pence per 1,000 gallons $= 1 + \frac{M}{75} + \frac{S}{60}$, where $M =$ McGowan figure* for the settled trade waste, and $S =$ figure for suspended solids in parts per 100,000.

There were certain trade wastes, e.g. gas liquors, to which the application of the above method might not be equable, but it did take into account a charge for screening, sedimentation, etc., for biological treatment and for sludge disposal.

Mr. J. R. Brown (Sewage Works Manager, Bingley), thought it was generally agreed that if all manufacturers paid something—if only a small amount—it would be less difficult for the sewage works manager to treat the trade effluents in his own district. If one approached a manufacturer who had just started up in business and told him he was liable to be charged for discharging his effluent to the sewer, he would immediately say: "Look at So-and-so; he has been established for so many years and he has to pay nothing." After all was said and done, the sewage works was as much the property of one manufacturer as another, because they were both ratepayers. It would level things out a little if all manufacturers were to pay to a certain extent. It was not so much that the local authority or the sewage works manager wished to receive a fee for accepting the trade waste, but it certainly helped indirectly in arranging the treatment.

One point had been stressed by Mr. Garner in the paper, but he would like to bring it forward again, and that was the necessity for co-operation and free discussion between manufacturers and the public officials. He felt at times that the Rivers Board was looked upon as a sort of police force but the Rivers Boards were really out to help both local authorities and traders.

Mr. Hardy said he was very pleased that Mr. Brown had stressed the help which local authorities, through the sewage works managers, were giving to the wool textile manufacturers. The case which he had quoted previously was a striking example of that point. It was a fact that in a certain area of the West Riding the sewage works manager cut down the water bill of a firm of textile manufacturers to 20 per cent. of the quantity formerly used.

Dr. J. Nixon (Huddersfield Sewage Works) said there was one point which must be borne in mind and which had not been mentioned. At a sewage works near the coast the sewage need not be purified to the same extent as at an inland sewage works which discharged into a stream. For example, at

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* A measure of the consumption of "dissolved oxygen" in five days.

Huddersfield a fair degree of purity had to be reached, whereas in the case of a sewage works on the sea coast or on a tidal stream only partial treatment need be given, by settling the sewage in tanks and discharging it on an outgoing tide ; the treatment was entirely omitted. Thus a trader who set up business near the coast could discharge his effluent to the local sewage works and the cost would be infinitesimally small compared to that of the traders inland.

A short time ago he came across a very Utopian scheme for overcoming the vexed problem of charges, and it was that all traders, whether in built-up areas or on the coast, should pay for their effluent on a sliding scale according to its strength, i.e. a manufacturer who discharged woolcombing effluent in, say, Bradford should pay as much as a coastal manufacturer who discharged woolcombing effluent. This money would be collected by a Central Board, who would allocate it, not evenly, but more to a sewage works which had to give more treatment than one which had to give less treatment. He did not know whether such a scheme was practicable or not, but it seemed to him the ideal system.

The Chairman had mentioned the use and recovery of certain oils in the textile industry, and this recovery was an essential part of many sewage works. He believed that in normal peace times olive oil was used to lubricate wool fibres, and he would like to know if the war conditions had caused any alterations in this matter.

Mr. Hardy remarked that since the war started substitute oils had been used for lubricating textile fibres, in place of olive oils of the Gallipoli type. The Gallipoli oils, which were formerly used almost exclusively on worsted yarns, had a high percentage of neutral saponifiable matter (the percentage of free fatty acids was up to about 10), and were emulsified by the use of soaps after a preliminary saponification with a very dilute solution of sodium carbonate. It was a two-stage action, and that type of effluent usually produced good recovered oil, which was known as the " recovered oleine type," because the free fatty acids were " cracked out " in the subsequent treatment. The substitute oils were not of the same chemical composition. Woollen mills largely used either distilled oils or recovered oils, also the lower grade " recovered black oils " as distinct from " blended black oils." The latter were right down at the bottom of the scale. The whole range of oils used would be represented by the firms in the Colne Valley. At the Huddersfield Sewage Works quite a large proportion of the lower-grade oils would be received.

Mr. J. H. Binns (Tyersal Combing Co. Ltd., Bradford), said he had been very interested in Dr. Nixon's remarks regarding the recovery of oil, and he thought the change at Huddersfield, so far as the worsted industry was concerned, was the use of nut oil instead of olive oil. In the combing trade it was found to be quite different, and, personally, it was not so much to his liking as olive oil.

He did not quite agree with Mr. Hardy that the acidity of olive oil was as high as 10 per cent. The oil as bought had a maximum of 5 per cent., but it might go up to 10 per cent. by oxidation on storing. He believed in the woollen industry they had been using a better class of oil for the lubrication of the woollen fibres. The idea of using less of the lower-grade oil and more of the better oil was to get a cleaner scour and a lighter shade on the fabric, particularly flannels.

He would like to ask Dr. Goldthorpe why, if there were no other reason than the oxygen content, they were expected to remove the suspended solids from the woolcombing effluents before discharge to the sewer. He assumed there was some other reason. It certainly was a costly procedure to remove the solids, necessitating as it did the provision of settling tanks, flock catchers, and so on. The disposal of the sludge constituted a difficulty, and would in the near future probably develop into a serious problem, unless some other method was found of dealing with it.

With regard to charges, a minimum of 6d. per thousand gallons had to be paid in Bradford for discharging untreated refuse to the sewers. Moreover, it did not rest at that. Calculation was made by means of the water meter ; a certain amount was estimated for domestic requirements, and the remainder was charged at 6d. per thousand gallons. It did not operate to the advantage of the manufacturer.

The point respecting prescriptive rights might be due to something rather more than a manufacturer having discharged his effluent to the sewers prior to March 3rd, 1937. In his own experience there had been periods when the local authority would not accept the trade effluent in any circumstances, because of the difficulty of treatment and the low price of the recovered grease ; then there came a period when the price of grease was good, and certain firms were compelled to turn all their effluent into the sewers. Varying periods of this type had occurred from time to time, and there was no doubt that some very old established firms had a certain amount of right to the positions they held to-day.

Arising out of Mr. Binns' remarks, Mr. Brown felt it would be helpful to manufacturers to mention that reasonably cheap recording instruments were available for the measurement of trade wastes. The ordinary flow recorder for use at sewage works was rather an expensive instrument, but for manufacturers a cheaper model could obtained. Some firms were able to give lower prices and better facilities where several manufacturers got together and placed an order for a number of instruments. Where, say, 20 recorders were ordered even better terms could be secured.

Mr. Foster Pickles (Leeds University) said there was one observation he would like to make on the question of sewage sludge and the making of it into manure for agricultural purposes. Some time ago one of his colleagues from the Agricultural Department of Leeds University told him he had been called in by a farmer to look at one of his fields which was growing a crop of flowers amongst the wheat. He went back with a collection of the flowers and traced them as having come from Persia and Asia Minor. He asked the farmer whence the fertiliser he had used had originated, and ascertained that it had come from a factory using mohair. The flower seeds had evidently been brought from those countries. It was therefore advisable to exercise a little care in using fertiliser from sludge.

With regard to some of the problems which had been raised, he did not know what Dr. Goldthorpe thought about large sewage works treating the sewage from smaller areas. They had been told that it was impossible for some of the smaller towns to provide sewage treatment for, say, a very large firm which might be set up in their district, and he thought it would be much better if the sewage from very wide areas were treated at one large works. He believed that in recent months the Bradford Corporation had come to an agreement with the Shipley Urban District Council to receive and treat their sewage on certain terms. It did seem that if authorities such as Bradford which had facilities available for treating sewage in large quantities could also treat the sewage from smaller surrounding districts, a saving would be effected in very many ways.

Another point which had been mentioned was in regard to firms situated on the coast or on tidal rivers. He wondered if the question had been considered of conveying the sewage and trade refuse from industrial towns to the sea and dumping it there without any treatment at all. There were very long pipe-lines for conveying water from the reservoirs to towns and cities many miles distant, and it seemed to him quite possible to transport sewage to the sea and avoid all the huge expense of treating it.

Mr. W. E. King (Department of Textile Industries, Bradford Technical College) said it did not seem to him quite fair that one manufacturer should have to pay for trade waste treatment and another should not. He could quite see the point that a firm should pay on the quality of the effluent, and he thought that was the fairest method of payment. It had been pointed out that various types of oil were being used. In Bradford less olive oil was being used because quite a lot of manufacturers were going on to emulsified creams.

Dr. Goldthorpe, in acknowledging a vote of thanks, said he had been amply repaid by the very interesting points raised in the discussion.

Mr. Pickles had commented on the use of sewage sludge as fertiliser. In Huddersfield, the sludge was heat-treated and all the weed seeds were killed, so that the farmer was in no danger of loading his land with tomato plants and the various flowers of Tibet!

The modern tendency was for centralisation of sewage treatment ; in a large scheme one trade effluent made very little difference to the flow as a whole, but questions of riparian rights might be involved if manufacturers began to take water from a river and allow it to pass away through one huge sewer to the sea.

With regard to Mr. King's remarks, one example of " prescriptive rights " was the case in Bradford quoted by Mr. Binns. Not only was there lack of uniformity in the charges made by the various authorities for the treatment of trade wastes, but charges varied within the areas over which one authority had control. There was some justification for prescriptive rights, because in certain cases local authorities had encouraged specific traders to discharge their wastes to the sewers, on account of some special advantage gained through the admission of those trade wastes. In Bradford's case it was the value of the recovered grease.

Greater uniformity in the charges made could be arrived at by frank and fair discussion among the traders themselves, and by friendly co-operation with the local authorities' representatives.

Mr. King had mentioned the creams used in fibre lubrication and the emulsifying agents employed. It was the function of a sewage works to destroy these emulsifying agents, by chemical, physical or biological means, so that a clear and sparking effluent could be produced. Emulsification was the exact opposite of what the sewage works manager had to do, and the addition of emulsifying agents to the sewage would only increase his difficulties.

COVENTRY'S PART IN THE DEVELOPMENT OF SYNTHETIC FIBRE

By G. Loasby, B.Sc., F.I.C.

The association of Coventry with the textile industry is a long one going back with certainty as far as the thirteenth century. It is well known that Coventry, centrally situated with regard to the raw materials of Yorkshire, Wales and the Cotswolds, was a producer in the time referred to of woollen broadcloths and velvets. Recently specimens were unearthed near the old " Drapery ", the site of the " Quality Control " in the middle ages, of felted woollen cloth in brown and black shades, and of rust coloured velvets of that period.

The existence of a body of experienced weavers, formed into the Guild of the Fullers and Weavers in the fifteenth century, and the introduction of the Quality Control Scheme in 1518, produced men and women in Coventry, who, skilled in the handling of natural fibres, passed down to their descendants not only the accrued experience of their trades, but the ability to apply their knowledge in the successful application and development of their synthetic textile fibres.

Their influence was further strengthened and enlarged with the establishment by Huguenot weavers in Coventry of the art of silk weaving, for its was on machines devoted to the use of real silk that the necessary modifications and adjustments were made that enabled the rayon industry to start its phenomenal career. In passing, it is worth noting that Sir Frank Warner states in his book on the " Silk Industry " that following the Revocation of the Edict of Nantes in 1685, upwards of 100,000 French people came to England in the space of two years. He traces the derivation of a number of typical Coventry surnames from French sources of this period, such as Beaufoy and Burgess, Smiles, Weir, Cockerell, Higgins, Bird, Young, White, Cross and King. A son of one of the immigrants named Bird became subsequently Mayor of Coventry.

The weaving of real silk, according to Poole, gave employment to upwards of 20,000 persons at one period in the first half of the nineteenth century in and around Coventry. In the petition to the House of Parliament in 1826 from the weavers, it was stated that there were 120 employers of weavers. In 1829 in a petition to the Board of Trade to establish a Wages Protest Bill there were 96 employers. Trade in the ribbon industry in the 50's was fairly prosperous until 1860 but the treaty with France in 1860 and the repeal of the silk duties created great unemployment. Only four firms survived this period of depression. Nevertheless by reason of the high quality and the design of high-class looms in Coventry, the art of weaving ribbons and smallwares is still carried out here.

The foregoing is stressed to show that there was in Coventry the sustaining power to survive all the vicissitudes of 800 years with ever-changing market conditions and unfavourable tariffs, the former necessitating new wares and competitive methods of production. It is not surprising, therefore, to find Coventry men fully conversant with known textile practice and foremost in the production and development of synthetic fibres. It may not generally be known that Coventry has had experience of the production of all the types of synthetic fibres used by the textile industry, and certainly Coventry has played a big part in the industrial development of two types.

The first pioneer in synthetic yarns was the late Mr. Joseph Cash, a member of the firm of J. & J. Cash (founded in 1856) who in 1896 at Wolston, a local village, endeavoured to manufacture nitro-cellulose rayon, called Woolstra or Wolstra, on a site now occupied by Messrs. Bluemels. Mr. Joseph Cash was at one time on the Committee of the Silk Association of Great Britain, and Chairman of the Textile Section of that body. The Artificial Silk Spinning Co. was formed with Mr. Cash as Chairman, Mr. Lazell as Secretary, the other directors being Messrs. Nye, Scott and Westerman. The Chairman at the Second Annual Meeting on December 30th, 1898, stated that he hoped soon to begin production of the collodion yarn, using the Chardonnet process. Difficulties were experienced with plant deliveries and insufficient capital. A further trouble was experienced with collodion setting or " conglutinating " in the pipes.

Sir Thomas Wardle, of Messrs. Wardle and Davenport, said in 1898 that there was a large demand for artificial silk in the Leek district. This was, to some extent, satisfied later by the establishment of the Tubize factory in Belgium of which Messrs. Fred and George Davenport were directors. This Tubize yarn was successfully used in Leek until the Davenports disposed of their interest in the Company.

The Wolston factory produced a small quantity of yarn for on December 23rd, 1898, Mr. Scott's wife and daughter went to a ball in dresses made from the yarn produced at the factory. The Company was reconstructed as the new Artificial Silk Co. Ltd. in 1899, but went into liquidation in 1900, the plant and effects being bought by Chardonnet and re-erected at the Glanzstoff factory at Aix-la-Chapelle. Thus ended Coventry's first adventure with rayon. During the period 1896-1900 Chardonnet was a frequent visitor to the town.

Coventry's introduction to the viscose process, which was patented by Cross and Bevan in 1892, took place in 1905. Capital for the development was found by the Viscose Syndicate Ltd. This syndicate, with Mr. Stearn at its head, was established at Kew primarily for the formation of filaments for incandescent lighting, but Mr. Stearn later formed his company after Topham's invention of the box, and after his expert mechanical skill had enabled spinning difficulties to be overcome, to exploit viscose as a textile material.

Courtaulds acquired at this time the British rights of Cross & Bevan, the

American rights being taken up by the American Viscose Company of Boston. These were subsequently taken over by Courtaulds Ltd. In 1904 Samuel Courtauld & Co. took over the Kew works and in 1905 removed the plant to Coventry. After enormous difficulties which used up all the capital allotted to its development, Messrs. Tetley and Latham persuaded Courtaulds' directors to advance more money and with this successfully conducted experiments which led to the production of a commercial thread.

By a strange coincidence the first customers of Messrs. Courtaulds were Messrs. Wardle & Davenport of Leek, who were intimately connected with the Wolston and Tubize projects. This firm can also claim the distinction of being the first knitters of rayon stockings which were made on machines manufactured by the firm of Wildt & Co.

The invention of the spinning box and filter candle by Topham with the Viscose Spinning Syndicate in 1900, was followed by other equally fundamental discoveries which enabled the industry to make advances both in quality and in production. Among these were the Clayton pump with rotating cylinder with connected pistons and cam pump B.P.17,876 of 1907, invented in Coventry, and the addition of glucose to the spinning bath by Wilson. Wilson in 1908 was also responsible for the combination of acid, glucose and ammonium or sodium sulphate for the spinning bath. Another advance in 1911 was the zinc patent of Napper in which a zinc salt was added to the bath.

Durafil, the Lilienfeld strong yarn with low extensibility, was experimented with and much work done in Coventry from 1926 onwards by spinning into strong sulphuric acid. Durafil up to this time was the strongest rayon known, having a wet tenacity in excess of the dry tenacity of any competitive yarn.

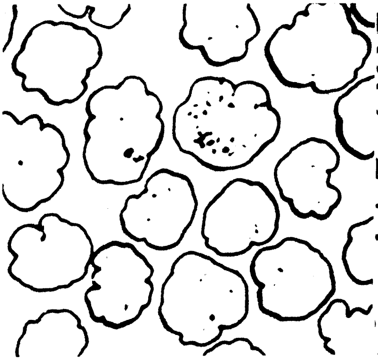
The year 1926 saw the invention by Glover and Heaven of the way to make dull yarn. Rayon first sold on account of its extreme brilliance, but yarns of high lustre have inferior covering power to yarns of similar construction with subdued lustre. This was the first patent to produce a dull yarn and many millions of pounds of yarn have been produced by incorporating in the spinning viscose highly dispersed colloidal globules of oil which cannot be removed by subsequent washing or extraction.

It would seem that with the great demand for viscose yarn and its world-wide development, little would be left unknown, but in 1935 following the discovery of increasing tenacity by hot stretching, Coventry developed Tenasco, which not only has a high strength but also a high extensibility.

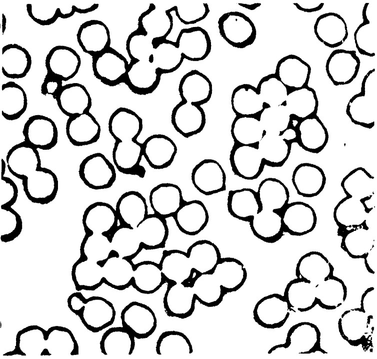
The year 1926 also saw the development of acetate yarns on a commercial scale in Coventry, followed by the erection of a factory solely to produce acetate fibres in 1927. The range of high-class bright and dull yarns of all deniers and filament counts was later extended by the addition of spun-dyed yarns fast to light and washing.

Staple fibre or " Fibro " has so far not been mentioned. The enormous production by the Totalitarian Countries of staple fibre as a substitute for cotton is largely determined by economic necessity, but the natural and logical development in England and the United States of Fibro (by making discontinuous lengths of rayon, patented by Pellerin 1907) as a new textile raw material having special qualities of its own follows on work done in Coventry in 1928, when the first supplies of raw material to be processed on a large scale on cotton looms were produced. Staple fibre bleached or spun-dyed of any denier and fibre length to blend with cotton or wool, or to use by itself as a textile yarn with rayon or wool dyeing properties (as Rayolanda X) is now available in viscose, acetate or casein.

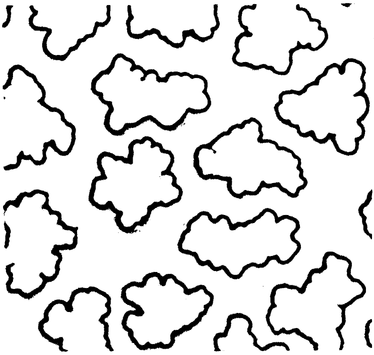
Those who know Cellophane (developed in Coventry for the factory at Bridgwater of British Cellophane Limited) to be viscose spun in a special continuous form, may recall the vogue some years ago of ribbon straw which, as Visca, was produced for the hat trade in flat continuous strips.



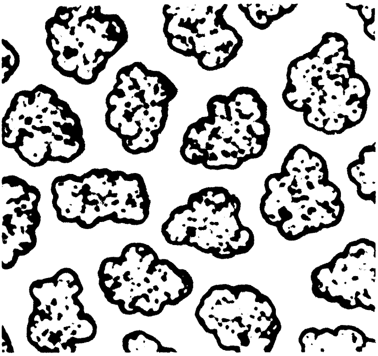
Casein
Rayon



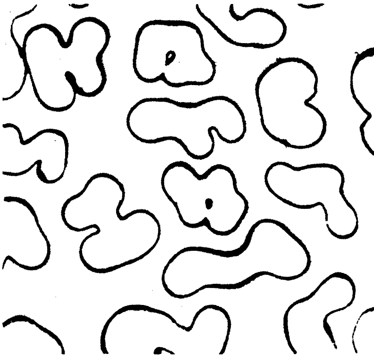
Cuprammonium
Rayon



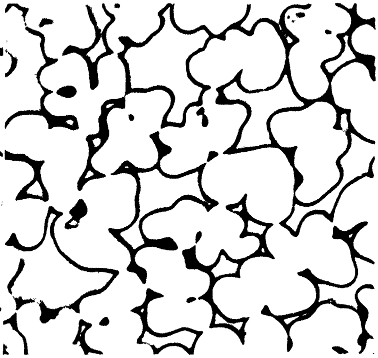
Viscose
Bright



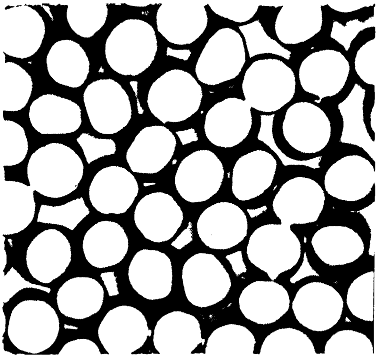
Viscose
Dull



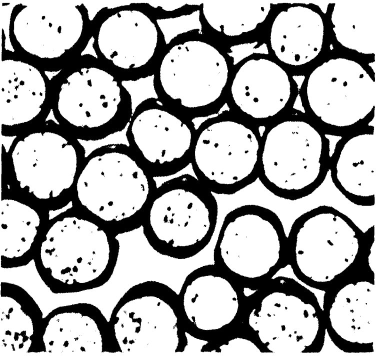
Nitro-cellulose
Rayon



Acetate
Rayon



Nylon
Bright



Nylon
Dull

The commercial development of cuprammonium yarn by the Thiele or stretch spinning process was undertaken in Coventry in 1927-28, a pilot plant being specially erected for the investigation and operated for a considerable period.

Of recent years prominence has been given to the economic production of protein yarns, casein yarn making its appearance under the name of Lanital, and also a mixed product of cellulose and casein, or "animalised" cellulose, with the trade-mark "Cisalfa" by the incorporation of casein in the spinning viscose. Casein fibre was first produced by Todtenhaupt in 1904 by spinning an alkaline solution into an acid bath. In 1935 Ferretti brought out his process, the English rights of which were taken up by Courtaulds and the process developed at Coventry. Notable steps in this work are the patents B.P.495,885 which deals with the treatment of casein with acetic anhydride, and the improvement in tenacity and resistance to hot water by the hardening process described in B.P.502,710.

Research is actively proceeding in several countries on the synthesis of new bodies capable of being formed into continuous filaments. Efforts have been made in many directions to produce fibres having not only the dyeing and other properties of natural silk, but its chemical character. From work in the United States by the du Pont Co. have emerged synthetic resins in their hundreds, formed by ringing the changes on the condensation of aliphatic dicarboxylic acids with aliphatic diamines or the substitution products of either or both. The chemistry of these is complex. From one of these, synthetic yarns known as nylon are being produced with tenacities in the wet state far in excess of the dry tenacity of real silk. They have complete resistance to bacteriological action and are entirely moth-proof. In addition to these qualities are others, such as their extensibilities in the dry state which are easily controlled, being of the order of real silk. The outstanding property of nylon is its recoverability from strain and distortion ; the elasticity surpasses that shown by other fibres.

Coventry is playing its part to-day in the development of nylon as a textile fibre.

The lecturer presented a series of tables and graphs to show the relative behaviour of nylon when loaded and its elastic behaviour when the load is taken off or reduced.

The following samples were exhibited:—

(1) Sample hank of nitro-cellulose made at Wolston by the New Artificial Silk Co., July, 1900.
(2) Hanks of viscose yarn made at Coventry, and bleached at Arques-la-Bataille, 1906.
(3) Hanks of viscose yarn, Coventry spun, in a Muller bath, 1907.
(4) Modern viscose yarn—bright and dull, spun in Coventry, 1940. (Hanks, cakes and cones.)
(5) Acetate yarn—bright and dull, spun at Coventry, 1940. (Cones.)
(6) Hanks of viscose yarn made at Kew, 103 denier, October, 1904.
(7) Viscose French bobbin spun yarn twisted into hanks, March, 1905.
(8) Early French viscose yarn spun into sulphuric acid alone. (Hanks.) 1905.
(9) Hanks of viscose yarn spun by the General Artificial Silk Co., U.S.A., 1908.
(10) Nylon yarn spun at Seaford, Delaware, U.S.A., 1939.
(11) Nylon yarn produced in America, 1940.
(12) Full-fashioned nylon hose, 51 gauge and 48 gauge, made in U.S.A., 1940.

Yorkshire Section

Presentation to Mr. W. Garner

In recognition of the work he has done for the Yorkshire Section of the Institute during his eight years as Honorary Secretary, Mr. Walter Garner, M.Sc., A.I.C., F.T.I., was presented with an inscribed silver cigarette case and a copy of the "Seven Pillars of Wisdom" by members of the Yorkshire

Section Committee at a committee meeting at the Midland Hotel, Bradford, on November 21. The presentation, which came as a complete surprise to Mr. Garner, thanks to the co-operation of his wife, was made by the chairman, Mr. Harry Hardy, who spoke enthusiastically of Mr. Garner's enterprise as Honorary Secretary of the Section, of the scientific contributions he has made to the textile industry through his writings and lectures, and of the prominent part he has played in the development of olive oil substitutes for the wool textile industry. Mr. J. R. Emms, immediate past-chairman of the Yorkshire Section, also spoke a few words in appreciation of Mr. Garner's services.

Replying, Mr. Garner remarked playfully that he " would never be able to trust his wife again " because of the way she had kept the presentation a secret from him. The enduring friendships he had made through his term of office as secretary were more than compensation for the work involved.

Mr. Garner is now vice-chairman, the secretaryship having been taken over by Mr. R. E. Masters.

Reviews

Insect Pests in Stored Products. H. Hayhurst, with photographs by H. Britten. (Published by Chapman & Hall Ltd., London, 1940 ; pp. 83+48 plates. Price 15s.)

During the last 25 years a vast amount of work has been done all over the world on the problem of insect pests attacking stored products, but so far only American and German text books have been available. Though many insect pests are cosmopolitan yet each region has its own peculiar conditions so that an insect prevalent in one country may be unknown in another. The lack of a general work dealing with pests found in Britain has long been felt and this book, based on Hayhurst's experiences in railway warehouses in this country, is an effort to meet this need.

It consists of text (pp. 1-48), control measures (pp. 49-54), a list of substances and their pests (pp. 55-83) and 48 plates giving 126 photographs of various adult insects and larvae.

The text describes the individual insects, and these descriptions together with Britten's excellent photographs—this is indeed the best illustrated book of its type that has yet appeared—form the really important and useful portion of the book and make its purchase well worth while. In addition to insects, mites are justifiably dealt with. The descriptions of the insects meet their purpose but the use of such phrases as " of a dark brown colour," " brown in colour," when " brown " alone suffices, is an inheritance from entomological literature which should have been discarded. It was surprising to read of *attagenus pellio* on p. 14 that " this larva is present in nearly every house." So far as this country is concerned this is quite untrue. For each insect a list of the products on which it has been found is given. If it were clearly stated which of these products actually served as food for the insect, the lists would have had more value, as it is both the lists of products infested by individual insects and the lists of insects found on individual products are liable to mislead any one approaching the subject with little knowledge of insects and their habits. It should never be accepted that an insect is a pest of any product merely because it has been found on it. As Hayhurst points out there are three possible explanations of an insect's presence, (*a*) it is feeding on the product or some impurity in it, (*b*) it is an accidental intruder, (*c*) it is parasitic on other insects or mites that are the real pests of the goods, but it is unfortunate he does not lay sufficient stress on these explanations in relation to the lists. Statements such as " has been found in warehouses, stocks of glass bottles " (p. 15) or " has been recorded on . . . . empty sacks . . . . warehouse walls and floors " (p. 15) are blots on the book. No insect eats glass bottles nor, in this country, sacks, nor warehouse floors or walls unless they are wooden. The insects were after something in or on the bottles, sacks, warehouses, walls or floors and since what this something was is not given the statements are valueless.

Under methods of control for use in warehouses Hayhurst rightly places proper storage conditions and strict cleanliness as of prime importance and this section is well worth taking to heart by all concerned in the storage of textiles whether in the form of raw fibres or finished pieces. It will be found, however, that a ½-1 per cent. sodium or ammonium bifluoride solution will be more efficacious than the 10 per cent. soda solution recommended by Hayhurst. The spraying of bales of raw wool or rags with such a bifluoride solution so as thoroughly to soak the outer layer is a great help in keeping down the moth pest more especially if the whole of the interior surface of the warehouse is sprayed with the solution once a month.

Foodstuffs are by far the most important of all stored products both in weight and in value, so as is natural and just the book deals mainly with such products, but the following textiles are listed as liable to infestation: Cotton, hair, raw and waste silk, sisal and wool. No other fibres are mentioned though linseed and hemp seed are. As is well known, wool and the other animal hairs are the only textiles likely to become pest-ridden in this country, though damage is done at times to sized textiles by various insects, e.g. flour moths, silver fish, cockroaches, in their efforts to obtain the size. Of the dozen insects listed as infesting wool three—*calandra granaria, c. oryzae* and *tribolium castaneum* are intruders which do not damage wool and evidence has yet to be produced to satisfy textile technologists that *tinea flavescentella, t. lapella* and *t. pallescentella* are true pests of wool though it is possible that they and a number of other moths may be able to live on the waste matters found in raw wool and on damaged wool substance, e.g. wool affected by moulds or bacteria.

The book would have been still more valuable if it had contained a list of references to the literature, e.g. the pamphlets of the Ministry of Agriculture, of the British Museum (Natural History) and of the U.S.A. Department of Agriculture as well as the vast amount of work on the protection of particular products against pests which is scattered in the various scientific, technical and trade journals and pamphlets.

A preface by T. W. Jones gives the genesis of the book and an account of the steps taken by the Department of Scientific and Industrial Research to deal with this problem of insect pests of stored products. C. O. CLARK.

General Items

New Members

Applications for membership have been received from the following:—

Ordinary.

BOWEN, E., B.Sc Hons., W. & T. Avery Ltd., Testing Machine Division, Soho Foundry, Birmingham (Manager, Testing Machine Division).

BOWMAN, W., Tycor Works, Waterford, Eire (Jute Works Manager).

DOIDGE, W. G., Meadow Head House, off 1, Beaumaris Avenue, Blackburn (Spinning Manager).

HAIGH, W., 145, Ravenshouse Road, Dewsbury, Yorks. (Instructor, Dewsbury Technical College).

JOHNSON, A. S., B.Sc., 175, Bury New Road, Breightmet, Nr. Bolton (Technical Service Department, Kirklees Ltd.).

LOVERING, C., British Celanese Ltd., 2, Bank Street, Manchester (Technical Assistant, British Celanese).

WAGGETT, G., 20, Starkie Street, Keighley (Undergraduate, Leeds University).

WARING, L. A. R., B.Sc., "Marguerite", Ulster Avenue, Dunmurry, Belfast (Research Assistant, Weaving Department, Linen Industry Research Association).

WEBSTER, R. T., 165, Chester Street, Blackburn (Loom Overlooker).

Junior.

GOOD, A. T., 72, Manchester Road, Haslingden (Assistant Manager Trainee).

GRIFFITHS, J. D., 65, Cornwall Street, Higher Openshaw, Manchester 11 (Textile Testing).

HUNT, D. N., 38, Sudbury Avenue, Ilkeston, Derbyshire (Works Chemist).

PARKER, R., 38, Fir Parade, Ravensthorpe, Dewsbury (Raw Material Clerk, Mark Day Ltd.).

SCATCHARD, T., 41, Kilpin Hill, Dewsbury (Blanket Merchant).

WILLOCK, J., 12, Brocklebank Road, Fallowfield, Manchester 14 (Textile Testing).

NOTICES: INSTITUTE MEETINGS

Tuesday,	7th January	*Manchester*—1.15 p.m. Meeting of the Diplomas Committee at the Institute.
Tuesday,	7th January	*Manchester*—2.45 p.m. Meeting of the Publications Committee at the Institute.
Wednesday,	22nd January	*Manchester*—1.45 p.m. Meeting of the Finance and General Purposes Committee at the Institute.
Wednesday,	22nd January	*Manchester*—2.45 p.m. Meeting of the Council at the Institute.
Wednesday,	29th January	*Manchester*—2.30 p.m. Meeting of the Joint Committee re National Certificates in Textiles, at the Institute.

YORKSHIRE SECTION

Thursday,	23rd January	*Bradford*—7.0 p.m. A.T.I. Evening at the Midland Hotel. Chairman: H. Hardy, Esq.

OTHER ORGANISATIONS

Blackburn Textile Society.

Friday,	10th January	*Blackburn*—Lecture: "The Manufacture of Aeronautical Fabrics," by W. Wilkinson, Esq., O.B.E., F.T.I. (Head of Technical College, Blackburn).
Saturday,	18th January	*Blackburn*—Visit to Corporation Gas Works, Greenbank, Blackburn.
Friday,	24th January	*Blackburn*—Lecture: "Faults Arising in the Weaving of High Grade Fabrics," by M. M. Taylor, Esq., Spondon.

Bradford Textile Society.

Monday,	6th January	*Bradford*—7.0 p.m. Lecture: "Wool Knowledge, General and Specialised," by H. Kenningham, Esq. (Bradford), at the Midland Hotel, Bradford.
Monday,	20th January	*Bradford*—7.0 p.m. Lecture: "Dyeing Problems in Wartime," by H. Jennison, Esq. (Messrs. Edward Ripley & Son, Ltd. (West) Bradford) at the Midland Hotel, Bradford.

British Association of Managers of Textile Works.

Saturday,	18th January	*Manchester*—6.0 p.m. Lecture: "Weaving of Heavy Fabrics," by Mr. Gerald K. Hall, of Bury, at the Victoria Hotel, Manchester.

Coventry Textile Society.

Saturday,	25th January	*Coventry*—2.30 p.m. Lecture: "Fibro", Rayon Staple Fibre Yarn—Spinning and Uses," by H. Ashton, Esq. (Arrow Mill, Rochdale), at the Technical College, the Butts, Coventry. (Illustrated by lantern slides.)

Dewsbury Textile Society.

Tuesday,	14th January	*Dewsbury*—Lecture: "Continental Methods of Carding in Relation to Present Problems," by R. W. Wright, Wool Industries Research Association, Leeds.

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ERRATUM.

Page P1. The word "appliances" in the title should be "auxiliaries."

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STANDARDISATION AND INDEX

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THE JOURNAL OF THE

TEXTILE INSTITUTE

STANDARDISATION

STANDARDISATION IN TEXTILES

REPORT FOR YEAR ENDING 31st DECEMBER 1939

Textile Divisional Council. The Agreement between the British Standards Institution and the Textile Institute called for the establishment of the Textile Divisional Council in order to complete the British Standards Institution's organisation. The British Standards Institution, in the early part of the year, drew attention to the desirability of implementing the agreement at the earliest possible date. The inaugural meeting of the Textile Divisional Council took place on October 5th. Plans had been prepared to mark this occasion by means of a luncheon but the disorganisation consequent upon the outbreak of war caused the abandonment of this plan. A report of the meeting appears in the Standardisation Section of the October issue of the *Journal of the Textile Institute*.

Representative Advisory Committee. This Committee met on the 5th October prior to the inaugural meeting of the Textile Divisional Committee with which it has a largely common membership.

Representative Advisory Committee Executive. The Executive met on June 12th, October 5th, October 30th and December 18th.

Divisional Committees. There has been little occasion for meetings of Divisional Committees during the current year as most of their wishes regarding work to be undertaken by the Technical Committees were expressed at meetings in 1938. Divisional Committee 5 met on 30th January, 23rd February 22nd June and 8th December to discuss its special problems. Divisional Committee 6 met on the 27th April and the majority of the replies to the questionnaire sent out at its request by the Unification of Testing Methods Committee have now been received for consideration by that Committee.

Unification of Testing Methods Committee and Technical Committees. Though the outbreak of war has caused some unavoidable delay in the work of these Committees it is intended to pursue the work with all possible speed. Technical Committee A and Technical Committee C have each held several meetings but have not met since the beginning of September. Matter for consideration by members of the Unification of Testing Methods Committee and Technical Committee A has been circulated and members have sent in their comments. It has been considered advisable on one or two occasions to invite such members of Technical Committee A as were interested to attend meetings of other Committees.

Technical Committee B met to consider Draft Specifications which have now been submitted to the Unification of Testing Methods Committee and have been accepted for publication as tentative standards.

Publication. A Standardisation Section was included in the June issue of the *Journal of the Textile Institute*. This included the report of the work of the Standardisation Scheme together with a Revenue Account to the end of 1938. Tentative Textile Standards Nos. 2 and 3 were produced in that number. The October issue contained a full report of the Inaugural Meeting of the Textile Divisional Council and Tentative Textile Standard No. 1.

COLLABORATION WITH THE BRITISH STANDARDS INSTITUTION. The British Standards Institution is called upon by various Government Departments to prepare and issue Standard Specifications. According to the terms of the agreement between the Textile Institute and the B.S.I. all Specifications containing matter relating to textiles are submitted to the Institute Standardisation Scheme before being issued as tentative standards. Several meetings have taken place in connection with British Standard, A.R.P. Series No. 23, covering the determination of the obscuration value of material for curtains. The introduction of the price clause necessitated the reference to the Cotton Board of the request for the production of a purchasing specification. As looms could not be liberated for the production of fabrics for curtains for black-out purposes the work on the purchasing specification was suspended. The Unification of Testing Methods Committee and Technical Committee A co-operated with the Cotton Board, the Shirley Institute, the Home Office and the National Physical Laboratory in the production of Specifications BS/ARP 23 and BS/ARP 29. These defined the method for the determination of the obscuration value of the materials for curtains and materials for blinds. BS/ARP 23 has been issued but BS/ARP 29 is held up at the request of the industry.

Other specifications such as 2F.55 covering Cotton Duck for cases and travelling packs for parachutes and BS/ARP Specification for the design of carrier for civilian respirator have been circulated to the Unification of Testing Methods Committee and Technical Committee A for criticism. The recommendations of members have been submitted in due course to the British Standards Institution.

INTERNATIONAL STANDARDS ASSOCIATION, HELSINKI, JUNE-JULY. The Technical Editor represented Great Britain on Committees 381, 38b and 40. A report of the proceedings was submitted to the R.A.C. Executive and accepted.

STANDARDISATION OF TESTING METHODS

MOISTURE CONTENT AND CONDITIONING

FOREWORD

In the testing of textile materials, the atmospheric conditions, to which the materials must be subjected prior to testing and under which these tests should be carried out, are stipulated whenever the determinations would be affected by the known sensitivity of the materials concerned to alterations of humidity and temperature. It is only by this means that uniformity of results can be obtained.

To avoid constant repetition of the details connected with the control of the atmospheric conditions in each standard specification, it is proposed to unify them in the form of definitions for purposes of reference. In due course, standardised methods for the determination of relative humidity, moisture content, regain, etc., will be laid down.

These definitions will therefore form a preface to the specifications of testing methods, and the following tentative drafts have been prepared.

TENTATIVE TEXTILE STANDARD No. 4, 1940

ATMOSPHERIC HUMIDITY AND THE MOISTURE CONTENT AND REGAIN OF TEXTILE MATERIALS

DEFINITIONS

Absolute Humidity and Relative Humidity. In works on physics the absolute humidity of the atmosphere is defined as the mass of water present per unit volume. The relative humidity is the ratio of the actual amount of water per unit volume to the amount necessary to saturate a unit volume at the same temperature and pressure. The relative humidity is usually expressed as a percentage.

Relative humidity is sometimes defined in another way. Dalton's law of partial pressures states that each gas or vapour in a mixture exerts its pressure independently of the others, each exerting the same pressure as if it alone occupied the whole space. Since the pressure is proportional to the density, the pressure due to a gas or vapour depends on the quantity present per unit volume. In a mixture which is saturated with water vapour, the pressure due to the water vapour is equal to the vapour pressure of liquid water at the same temperature. The ratio of the actual pressure of the water vapour in the atmosphere to the vapour pressure of liquid water at the same temperature is the relative humidity. The relation between the temperature and the corresponding pressure of saturated water vapour is very closely similar to that between the temperature and the mass of water present per unit volume of saturated atmosphere. Hence this method and the one quoted above give practically identical results.

Dew Point. The amount of moisture necessary to saturate unit volume of the atmosphere decreases as the temperature decreases. If air containing moisture is cooled, it approaches the state of saturation which is indicated by the phenomenon of condensation. The temperature at which condensation begins is known as the dew point.

Moisture Content of Textile Materials. The amount of moisture in a material when expressed as a percentage of the total weight is known as the percentage moisture content.

Regain of Textile Materials. When the moisture present in a textile material is calculated as a percentage on the oven-dry weight the percentage is known as the regain.

If 100 parts by weight of material contain 20 parts by weight of water, the moisture content is 20% and the regain is $100 \times 20 \div 80$ or 25%.

Standard Regains. Standard regains are arbitrary values chosen as the most useful for commercial purposes. The correct conditioned or "correct invoice weight" of a consignment shall be calculated from its oven-dry weight and the recognised standard regain.

The various textile fibres, and the yarns and cloth made therefrom, have more or less arbitrary percentage moisture contents and regains accredited to them, so that for trade purposes they may be declared "in correct condition" when they contain the recognised percentages of moisture or the equivalent "regain."

The following "standards of regain" have been proposed and are commonly but not universally accepted.

	Standard Moisture Content	Standard Regain
	Per cent.	Per cent.
Cotton	7·83	8½
Silk	9·91	11
Flax and Hemp	10·71	12
Jute	12·09	13¾
Wool and Waste	13·79	16
Wool (Tops combed with oil)	15·97	19
Wool (Tops combed without oil)	15·43	18¼
Worsted Yarns	15·43	18¼
Carded Woollen Yarns	14·53	17
Wool Noils (ordinary)	12·28	14
Wool Noils (scoured and carbonised)	13·79	16
Woollen and Worsted Cloths	13·79	16
*Viscose and Cuprammonium	9·91	11
*Acetate Rayon	5·66	6

* According to the B.I.S.F.A. Regulations, other standards obtain in certain circumstances.

In the original setting up of these standards it was assumed that when 100 parts of the fibre, in the oven-dry state, were exposed to the " usual condition of the atmosphere," they would take up or " regain " moisture to the extent shown by the percentage moisture contents and the regains in the above table.

When the moisture contents and the regains of the materials accord with the standards shown in the table, they are regarded as " 100% in correct condition."

Example.—A sample of cotton is found to contain 11% moisture.

Then	Dry weight ..	89%
	Moisture ..	11%
		100%

The percentage of " cotton in correct condition " is given by the relation 100 : 108½ : : 89 : (percentage of cotton in correct condition) and its value is 96·565%.

Applying this percentage of " cotton in correct condition " to the bulk weight of the cotton which the sample represents, say 2,000 lb.

100 : 96·565 : : 2,000 : 1931·3, 1931·3 lb. being the correct invoice weight of the bulk in question.

This is the weight of cotton to be debited to the buyer.

Equilibrium Regain. The regain of a textile material increases or decreases in correspondence with changes in the relative humidity of the atmosphere to which it is exposed and, to a smaller extent, with changes in the temperature. After being exposed for a sufficient time to an atmosphere of which the relative humidity and the temperature are kept constant, the regain of the material reaches a steady value known as its equilibrium regain. The actual value of the equilibrium regain corresponding to given atmospheric conditions depends upon the direction from which the equilibrium is approached owing to the phenomenon of hysteresis.

Standard Atmosphere. The results of mechanical and other tests on textile materials are affected by the amount of moisture present in the materials. Prior to testing, materials should therefore be " conditioned " by exposure under standard conditions of relative humidity and temperature. In this country and the U.S.A. the conditions denoted by $65\% \pm 1\%$ relative humidity at $70^\circ \pm 2^\circ$ F. are coming into wider use. On the Continent $65\% \pm 1\%$ and $20^\circ\,{}^{+5^\circ}_{-2^\circ}$ C. are laid down, the greater tolerance on the temperature being allowed in order to obviate as far as possible the need for refrigeration during part of the summer.

TENTATIVE TEXTILE STANDARD No. 5, 1940

DETERMINATION OF RELATIVE HUMIDITY

In the normal circumstances in which textile materials are processed and tested, the ventilated wet and dry bulb hygrometer and the sling hygrometer are the most convenient instruments and are sufficiently accurate for the determination of relative humidity.*

The Ventilated Wet and Dry Bulb Hygrometer. This instrument consists essentially of a pair of matched thermometers, calibrated accurately to one half of a degree Fahrenheit. The bulb of one is left bare while that of the other is covered with a close fitting sleeve of muslin or other open cotton fabric. The thermometers are mounted in polished metal tubes so that the air, of which the relative humidity is to be determined, can be drawn over the bulbs by means of a clockwork-driven fan or otherwise at a velocity not less than 10 feet per second. Prior to making a test, the fabric covering the wet bulb thermometer is thoroughly wetted with distilled water. Observations of the readings of the thermometers are made while the air is drawn past the bulbs and the steady readings are noted. From the available psychrometric tables† the relative humidity of the air can then be found. It is recommended that an instrument of this type be accepted as a standard.

The Sling Hygrometer. In this instrument the wet bulb thermometer and the dry bulb thermometer are secured in a frame which can be whirled round so that the thermometer bulbs move through the air at 10 to 20 feet per second. The apparatus should be whirled for at least 30 seconds if sensitive thermometers with thin-walled bulbs are used, and for 60 seconds if the thermometers have thick-walled bulbs. After reading the thermometers, the hygrometer should be again whirled and fresh readings should be made. It is necessary that the tests be repeated until identical successive readings are obtained.

Other Instruments. Instruments which depend upon the changes consequent upon the absorption of water from, or loss of water to, the atmosphere by a sensitive material such as human hair or goldbeater's skin are available in considerable variety. These should not be used in cases of dispute and should be calibrated regularly by comparison with a standard hygrometer throughout the range of the instruments.

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* Other methods capable of giving greater accuracy are available in physical laboratories. These depend on the direct determination of the dew point or the weighing of the moisture in a measured quantity of air.

† Various empirical relations connecting the wet bulb and dry bulb temperatures with the dew point have been derived and tables have been computed to obviate the calculation of the relative humidity. Glaisher's "Hygrometric Tables adapted for the Use of the Dry and Wet Bulb Thermometer" apply only to the unventilated instrument in "still air." Since the measurement of relative humidity by means of the unventilated wet and dry bulb hygrometer is unreliable, Glaisher's tables are no longer used in scientific work. The Meteorological Office Tables for use with instruments exposed out of doors in Stevenson screens apply to "light airs." For the ventilated hygrometer and the sling hygrometer the Prussian Meteorological Institute issue the "Aspirators Psychrometer Tafeln" which have been amplified at the National Physical Laboratory, Teddington. The tables appearing in the Appendix to the Standards on Textile Materials prepared by Committee D13 of the American Society for Testing Materials are based on the Smithsonian Meteorological Tables. The Psychrometric Tables by C. F. Marvin, published by the U.S. Department of Agriculture Weather Bureau and obtainable in this country from Messrs. C. F. Casella & Co., Ltd., Regent House, Fitzroy Square, London, W.1., are convenient and are used fairly generally.

BRITISH STANDARD SPECIFICATIONS

Many of the specifications which the British Standards Institution has drafted in the past on behalf of the Services or other Government Departments deal, directly or indirectly, with textile materials. The agreement between the Textile Institute and the British Standards Institution ensures that specifications referring to textile materials will be submitted to the Textile Institute prior to being issued in final form. Further, as existing specifications come up for revision, they will be submitted to the Textile Institute for approval or amendment as regards the specifically textile clauses.

The following Draft Specifications, BS/ARP 23, 2 F. 55 and Cheese Cloth and Butter Muslin, have already been circulated for comment to Technical Committees working under the Textile Institute Scheme for Standardisation in Textiles. Suggestions from any source will be welcomed and these will be passed by the Textile Institute to the British Standards Institution.

BS/ARP 23. [Draft.

BRITISH STANDARD SPECIFICATION (A.R.P. SERIES)
FOR THE

OBSCURATION VALUE FOR TEXTILE MATERIAL FOR CURTAINS AND METHOD OF TESTING

This Standard forms one of a series of Specifications prepared by the B.S.I. at the request of the Air Raid Precautions Department of the Home Office. Its object is to assure purchasers and manufacturers of textile material for curtains purporting to be sufficiently opaque to secure the necessary obscuration for complying with the provisions of the Lighting Order, that the materials comply with those requirements.

1. Obscuration Value*

The average of the tests on at least four samples (taken as in Clause 3), of the total light passing through the material, when tested as in Clause 2, shall not exceed 0·001 per cent. of the light incident upon the material, and the light passing through any sample shall not exceed 0·003 per cent.

2. Method of Testing

The obscuration value of the material shall be determined by measuring the amount of light transmitted by a single layer of the material immediately in front of a bright sensibly colourless diffusing screen. The method must be such that effectively all the light passing through the material—irrespective of direction—is included in the measurement. For practical purposes one way to achieve this is to place close in front of the material a second sensibly colourless diffusing screen. The percentage transmission may be determined by measuring the brightness (by any suitable means) of this second diffusing screen, with and without the material in position between the two screens. A source of light of high intensity, such as a 1,000 watt tungsten-filament projector-lamp, is desirable.

One suitable method of measuring this brightness is by means of a photo-electric photometer, of which the emission photo-cell and amplifying valves are contained in a metal box, in the front face of which the second diffusing screen forms a window. The screen nearer the lamp may conveniently be about 5 inches in diameter, and the other screen not less than 2½ inches in diameter, or square shaped with sides of these dimensions. The photo-cell box is fixed in position with its diffusing screen as close as possible to the first diffusing screen, and directly opposite to it. Owing to the large ratio of the intensities to be measured, it may be found necessary in the case of the open reading to reduce the illumination on the first diffusing screen by increasing its distance from the lamp ; the inverse square law can then be used to calculate the reduction effected. A further decrease in the ratio can, if necessary, be produced by a neutral filter of known transmission. Care should be taken that the sensitivity response of the photo-cell to light of different wave lengths is sensibly the same as that of the eye, and it may be necessary to use light filters to achieve this object.*

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* Some criticism of the value of 0·001 per cent. has been made on the ground that the test thereby becomes needlessly stringent. It should be pointed out, however, that the Committee responsible for the specification were asked to embody this figure, which was laid down by A.R.P. Department of the Home Office.

3. Sampling

Owing to the natural variability of textile materials, samples shall be taken from a full width piece of the cloth at least one yard long. The samples shall be taken from positions equally spaced along a diagonal.

4. Marking

Materials which comply with the requirements of this Specification may be marked or labelled " Obscuration to BS/ARP 23 ".

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2 F.55. [Draft.

BRITISH STANDARD SPECIFICATION FOR

COTTON DUCK (DYED) FOR CASES AND TRAVELLING BAGS FOR PARACHUTES

FOR AIRCRAFT PURPOSES

1. Quality of Yarn

(*a*) The yarns used in the manufacture of the fabric shall be spun from a good quality cotton. They shall be level and free from avoidable defects.

(*b*) Both the warp and weft yarns shall be three-fold.

2. Weave

(*a*) The weave shall be a plain weave.

(*b*) The ends and picks per inch shall be not less than 43 and 35 respectively.

(*c*) The fabric shall be uniformly woven and shall be as free as possible from defects of preparation and of weaving ; the selvedges shall be evenly and well made.

3. Colour and Finish

The fabric shall be piece dyed with chrome iron compounds. The colour and finish shall be as specified by the Purchaser in the contract or order.

4. Width

The width at any part shall be not less than that specified and shall not differ from the width at any other part by more than ¼ inch.

5. Weight

The weight of the fabric, when determined by the method described in Appendix I, shall be not more than 12 oz. per sq. yard.

---

* When photo-electric photometer test results on a comprehensive range of fabrics are available, it may be possible, by a visual method, qualitatively and rapidly to compare new samples with samples of known obscuration values.

6. Freedom from Impurities

(*a*) The water extract of a sample of the fabric, prepared and tested as described in Appendix II, shall have:—

(i) a *p*H value of not less than 5 nor greater than 9, and

(ii) an iron content of not more than 0·01 per cent. by weight referred to the weight of the cloth.

(*b*) The alkali content, calculated as anhydrous sodium carbonate, determined by the method described in Appendix III, shall not exceed 1·5 per cent. by weight of the fabric.

7. Strength

The breaking strength of any specimen, when determined by the method described in Appendix IV, shall be not less than 100 lb. per inch width of warp or weft.

8. Selection of Test Samples

A sample 36 inches long and the full width of the cloth shall be selected from each consignment, where it can be shown that the whole consignment can be correlated with a particular warper's beam. In other cases the selection of samples shall be left to the Inspector's discretion, at least one sample 36 inches long and the full width of the cloth being selected from one roll in every consignment of 20 rolls or less.

APPENDIX I

Method for the Determination cf Weight

A piece of the selected sample of suitable size (not less than 12 inches square and clear of the selvedge) shall be conditioned for not less than 6 hours (or in case of dispute for not less than 48 hours) in an atmosphere with a relative humidity of 65 per cent. and a temperature of 70° F., and then weighed under the same conditions.

APPENDIX II

Methods for the Determination of *p*H Value and Iron Content

(*a*) *p*H *Value*. Five g. of the material, cut into pieces about one inch square shall be boiled for one hour in 100 ml. of neutral distilled water in a chemically resistant glass flask. The flask shall then be stoppered and allowed to cool to room temperature. The liquid shall be made up to 100 ml. with recently boiled and cooled distilled water (liquid A) and a portion of the liquid then withdrawn and the *p*H value determined. In case of dispute, the *p*H value shall be determined by the electrometric method using a glass electrode.

(*b*) *Iron Content*. For the determination of iron, the liquid (A) shall be filtered and 25 ml. withdrawn and placed in a 50 ml. standard flask. Two drops of pure thioglycollic acid shall be added, followed by sufficient pure ammonia solution of specific gravity 0·880 to make the liquid distinctly alkaline, and the whole shall then be made up to 50 ml. with distilled water. This liquid (B) shall be placed in a suitable colorimeter and compared with liquid (C) made up from a standard iron solution.

The standard iron solution shall be prepared by dissolving 0·1 g. of iron wire in hydrochloric acid, evaporating to dryness, dissolving the residue in distilled water containing 1 ml. of hydrochloric acid, and diluting to one litre with distilled water. This liquid shall be diluted with 9 times its volume of distilled water to form a standard solution containing 10 parts of iron per million or 0·01 mg. of iron per ml. From 1 to 10 ml. of the standard iron solution as required shall be placed in a 50 ml. standard flask with 1 ml. of N. hydrochloric acid, two drops of pure thioglycollic acid, and sufficient ammonia solution to make the liquid distinctly alkaline. The whole shall then be made up to 50 ml. with distilled water, liquid (C).

APPENDIX III

Method for the Determination of Alkali Content

1g. of the material cut into pieces about 1 inch square shall be placed in a chemically resistant glass flask and thoroughly wetted by boiling with 30 ml. of distilled water. The mixture shall be cooled to room temperature and without removal of the cloth, 10 ml. N/10 hydrochloric acid shall be added and the whole allowed to stand for 15 minutes. The excess acid shall then be titrated with N/10 caustic soda, using methyl orange as indicator, and the alkali content of the cloth calculated as anhydrous sodium carbonate.

APPENDIX IV

Method for the Determination of Breaking Strength

At least six test specimens 2½ inches wide shall be cut from the test sample in the direction of the warp and at least six in the direction of the weft. No two specimens cut in the same direction shall contain the same longitudinal threads.

The threads shall be frayed out from the sides of each specimen so as to reduce the width to 2 inches, and each specimen shall be fixed in an approved testing machine of constant rate of traverse type, so that the length between the supports is 7 inches. The capacity of the machine shall be about 1,000 lb., and the rate of traverse 18 inches per minute.

The test shall be carried out under ordinary atmospheric conditions, but in cases of dispute the specimens shall be conditioned for not less than 48 hours in an atmosphere with a relative humidity of 65 per cent. and a temperature of 70° F., and then tested under the same controlled conditions.

THIRD REVISED DRAFT

BRITISH STANDARD SPECIFICATION FOR

CHEESE CLOTH AND BUTTER MUSLIN

FOREWORD

The preparation of this British Standard was authorised by the Dairy Standards Committee of the Chemical Divisional Council.

It is intended to provide for the ordinary cheese cloths and butter muslins as used in Great Britain. In Australia, New Zealand and other countries in the British Commonwealth, tubular cheese bandages are almost exclusively used and they are now finding an increasing use in this country. A specification for tubular cheese bandages is in the course of preparation which will be issued in due course as Part 2 of this specification.

In order to keep abreast of progress in the industries concerned, the British Standards are subject to periodical review.

Suggestions for improvements addressed to the British Standards Institution, 28, Victoria Street, London, S.W.1, will be welcomed at all times. They will be recorded, and in due course brought to the notice of the Committees charged with the revision of the Publications to which they refer. Suggestions made to the Textile Institute will be duly transmitted to the British Standards Institution.

CHEESE CLOTH

1. Material

British Standard Cheese Cloth shall consist of cotton fabric, grey or loom state, treated with suitable sizing material and shall be free from anything which may contaminate or be deleterious to the foodstuffs wrapped.*

2. Width

The material shall be 52 in. in width unless otherwise agreed between Purchaser and Vendor.

3. Sizing

The sizing present in the material shall not exceed (*a*) pure sized 10%, (*b*) lightly sized 25%, (*c*) heavily sized 100%.

4. Threads per in. and Count.

The percentage of sizing is to be added to the *grey warp yarn only,* and, therefore, is not a percentage of the total weight of the material. The threads per in. and the count shall be the average of six determinations. The particulars of the various types of cheese cloth shall be in accordance with the figures given in the following table, the count of the yarn being taken in the grey and unsized state.

Description of Cloth		†Threads per in.		Counts of Yarns	
		Reed	Pick	Warp	Weft
Cheese Grey, Pure Sized	(*a*)	56	54	32	40
	(*b*)	58	49	44	54
Cheese Grey, Heavily Sized	(*a*)	46	38	38	30
	(*b*)	47	37	26	30
Cheese Grey Caps, Pure Sized	(*a*)	56	54	32	40
	(*b*)	56	52	38	54
	(*c*)	58	49	44	54
Cheese Grey Caps, Heavily Sized	(*a*)	42/3	25/6	36	46
	(*b*)	43	26	34	54
Cheese Roller Bands, Lightly Sized	(*a*)	60	54	36	54
Pure Sized	(*a*)	62	38	32	46
	(*b*)	64	60/61	36	21
Heavily Sized	(*a*)	47	37	26	30

5. Tensile Strength

The tensile strength of the various types of cheese cloth, when determined by the method described in the Appendix, shall not be lower than the value given in the following table:—

Description of Cloth		Tensile Strength (minimum) lb.	
		Warp	Weft
Cheese Grey, Pure Sized	(*a*)	84	66
	(*b*)	85	43
Cheese Grey, Heavily Sized	(*a*)	85	67
	(*b*)	112	59
Cheese Grey Caps, Pure Sized	(*a*)	84	66
	(*b*)	82	58
	(*c*)	85	43
Cheese Grey Caps, Heavily Sized	(*a*)	66	29
	(*b*)	85	22·5
Cheese Roller Bands, Lightly Sized	(*a*)	114	52
Pure Sized	(*a*)	117	34
	(*b*)	99	119
Heavily Sized	(*a*)	112	59

---

* Attention is drawn to the requirements of the Food and Drug Regulations.

† Using a 1 in. glass.

6. Sampling

Samples shall be taken at random from not less than the following percentages of the total number of packages composing each delivery and each size.

Up to 50 packages—not less than 10 per cent.
Over 50 ,, —not less than 5 per cent. with a minimum of 6 packages.

(*a*) *Rolls.* A sample shall consist of a length of 8 inches taken the full width of the roll, the first and last yard of the roll not being used for test purposes.

(*b*) *Cut pieces.* A sample shall consist of a minimum of 6 pieces, each piece having minimum dimensions of 8 in. × 4 in., the first 6 and the last 6 pieces not being used for test purposes.

The pieces taken for the determination of count shall be so selected that no two test pieces for the warp count shall contain the same warp yarns, or for the weft count, the same weft yarns.

BUTTER MUSLIN

1. Material

British Standard Butter Muslin shall consist of pure bleached cotton fabric, thoroughly scoured, and free from anything which may contaminate or be deleterious to the foodstuffs wrapped.*

2. Threads per in. and Count

The threads per in. and the count shall be the average of six determinations. The particulars of the various types of butter muslin shall be in accordance with the figures given in the following table, the count of the yarn being taken in the grey and unsized state:—

	†Threads per in.		Counts of Yarn	
	Reed	Pick	Warp	Weft
Type A	54	51	38	54
Type B	43	30	42	56
Type C	45	33	44	44
Type D	58	51	36	46

3. Tensile Strength

The tensile strengths of the various types of butter muslin, when determined by the method described in the Appendix, shall not be lower than the value given in the following table:—

	Tensile Strength (minimum) lb.	
	Warp	Weft
Type A	82	58
Type B	67	25
Type C	53	31
Type D	99	51

---

* Attention is drawn to the requirements of the Food and Drug regulations.

† Using a 1 in. glass.

4. Sampling

Samples shall be taken at random from not less than the following percentages of the total number of packages comprising each delivery and each size:—

Up to 50 packages—not less than 10 per cent.
Over 50 ,, —not less than 5 per cent. with a minimum of 6 packages.

A sample shall consist of a length of 12 inches taken the full width of the roll, the first and last yard of the roll being discarded for test purposes.

The pieces taken for the determination of count shall be so selected that no two test pieces for the warp count shall contain the same warp yarns, or for the weft count, the same weft yarns.

APPENDIX

METHOD FOR THE DETERMINATION OF TENSILE STRENGTH

Conditioning of Samples

Immediately prior to testing, the samples shall be conditioned for a minimum period of 6 hours in an atmosphere kept at a relative humidity of 65-70 per cent.

Apparatus

A suitable type of apparatus is the "Goodbrand" machine which has a capacity of 400 lb. and a rate of traverse of 18 in. per minute.

Test Pieces

The dimensions of the test pieces shall be 7 in. × 4 in. between the jaws of the testing machine.

Method

The specimen to be tested shall be placed symmetrically in the clamps of the machine.

The average of the results of 6 tests shall be taken as the ultimate tensile strength. Any result which is markedly below the average and which is solely attributable to faulty operation or slipping or breaking in the clamps may be discarded and another specimen taken, and the result of this break included in the average.

THE JOURNAL OF THE
TEXTILE INSTITUTE

STANDARDISATION

STANDARD METHOD FOR TESTING THE FASTNESS TO LIGHT OF COLOURED TEXTILE MATERIALS

It will be recalled that in 1937 an agreement was made between the Textile Institute and the Society of Dyers and Colourists, the Society being thereby recognised as the appropriate organisation to standardise methods of testing the fastness to light of coloured textile materials. The work published by the Society in 1934 was then being extended and as a result new sets of standards are now available. The following account of the work has been written by Mr. L. A. Lantz, Chairman of the Committee of the Society responsible for the work.

The research work on fastness of coloured textile materials initiated by the Society of Dyers and Colourists in 1927, resulted in the selection of two parallel series of dyed standards of Fastness to Light, the description of which is given in the Society's "Report on the work of its Fastness Committee in fixing Standards for Light, Perspiration and Washing", published in 1934.

These two series of Standards, a red and a blue one, each comprised seven dyeings of increasing degree of fastness, numbered 2 to 8, and graded in such a manner that each member of the series was approximately twice as fast as the preceding one. They represented 8 grades of fastness to light, No. 8 being the highest grade. It was not thought necessary at the time to have a dyed standard for the lowest grade, anything not as fast as No. 2 being classified as 1.

After the publication of the Society's report, comments on the Standards were invited and close contact was established with Echtheitskommission of the Society of German Chemists and the Fastness Committee of the American Association of Chemists and Colorists which had each selected their own set of standards for Fastness to Light. Results were compared, and the possibility discussed of agreeing on a common range which would subsequently, it was hoped, be adopted internationally. At the same time, the Society's Fastness Committee carried out further research amongst suitable dyestuffs with a view to improving such of the Standards as were known not to be quite satisfactory.

Although it was not found possible to reach complete agreement on all the Standards with the above-named Societies, considerable progress was made.

The Society of Dyers and Colourists is now in a position to submit an improved set of Standards for publication as Tentative Standards for Fastness to Light, in accordance with the agreements made between the Society and the Textile Institute and between the Textile Institute and the British Standards Institution.

The new series consists of 8 blue dyeings, including one for No. 1, and the parallel red series has been abandoned as superfluous. The Standards are dyed on wool as before.

The dyestuffs used are as follows:—

Nos.		
1	0·8%	Brilliant Wool Blue FFR extra (I.G.).
2	1·0%	Brilliant Wool Blue FFB extra (I.G.).
3	1·2%	Brilliant Indocyanine 6B (I.G.).
4	1·1%	Polar Blue G conc. (Gy).
5	0·8%	Solway Blue RS (I.C.I.).
6	2·5%	Alizarine Light Blue 4GL (S).
7	2·5%	Soledon Blue 4BC pdr.(I.C.I.).
8	3·0%	Indigosol Blue AGG (I.G.).

The Standards are obtainable from the Society of Dyers and Colourists in sets 4½ × 3″ at the price of 5/- per set.

In use, they are exposed, together with a piece of the material to be tested, for a sufficient length of time to cause a definite fading of the latter. This is then given the fastness number of the particular standard which has faded to the same extent. It is of course unnecessary to expose the full series of Standards in every case, especially when the fastness of the material to be tested is approximately known, but even in such case, it is recommended to use at least two adjacent standards for ease of comparison.

The Standards are particularly valuable for daylight exposures as they allow reliable fastness figures to be obtained not only under all conditions of light, but also in different climates, because the dyeings selected for the Standards are little affected by variations in atmospheric humidity and temperature.

If an artificial light source is used, this should give as close an approximation to daylight as possible. Fading Lamps using the popular enclosed carbon arc should include devices for controlling the humidity and temperature of the atmosphere surrounding the samples, so as to give a close imitation of various climatic conditions. If the samples are disposed circularly around the arc, they should be mounted on a rotating device to equalise the distribution of the light.

With such an artificial light source in which the light is reasonably constant, and fastness measurements are generally based on time of exposure, the Standards will nevertheless be found very valuable for calibrating the lamp and controlling the exposures.

It must be emphasised that these Standards constitute merely a measuring device in the form of an evenly graded scale of fastness to light, which enables colour fastness to be expressed in figures. They are therefore not commercial Standards in the sense of directly defining certain commercial classes of dyed or printed goods, but are intended to be instrumental in the definition of such classes.

Thanks are due to the Wool Industries Research Association, and to the individual members of the Fastness Committee for assistance in carrying out exposures and preparing the dyed Standards.

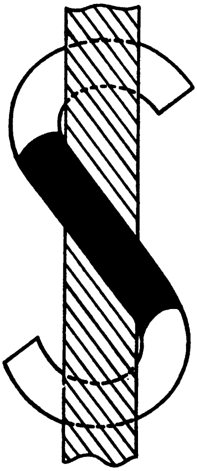
BRITISH STANDARD (TEXTILE) No. 2, 1939

Published as a Tentative Textile Standard in June 1939. As provided in the Textile Institute Standardisation Scheme, this Standard has now been revised and will be issued by the British Standards Institution as a British Standard (Textile)

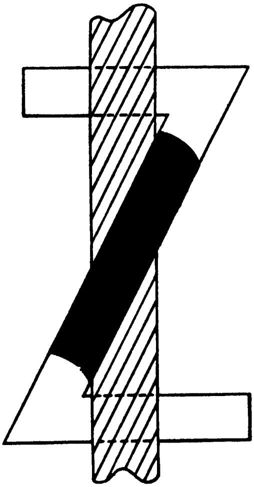
DESIGNATION OF TWIST IN SINGLE YARNS, FOLDED YARNS AND CABLES

Single Yarns

A yarn has "S" twist if, when it is held in the vertical position, the spirals conform in direction of slope to the central portion of the letter "S". Similarly, the yarn has "Z" twist if the spirals conform in direction of slope to the central portion of the letter "Z". These are illustrated below.



'S' TWIST



'Z' TWIST

Folded Yarns and Cables

The direction of twist in successive twisting operations is described by a series of letters "S" and "Z" in which the first letter or group of letters gives the direction of twist in the single yarns. The letter (or letters) referring to the single yarns may, if desired, appear in smaller type.

Twist in folded yarns is designated "S/S" or "Z/Z" when the folding turns are in the same direction as those in the single yarns.

When folding twist is in the opposite direction to that in the single yarns, the designation is "S/Z" or "Z/S", and in successive cabling operations, yarns may be shown as "S/Z/S......" or "Z/S/Z......".

When single yarns of opposite twist are folded, the designations are "SZ/S" or "SZ/Z" according as the doubling twist is in the "S" or the "Z" direction.

BRITISH STANDARD (TEXTILE) No. 3, 1939

Published as a Tentative Textile Standard in June 1939. As provided in the Textile Institute Standardisation Scheme, this Standard has now been revised and will be issued by the British Standards Institution as a British Standard (Textile)

EXISTING YARN COUNT SYSTEMS AND CONVERSION OF COUNTS

Length per Unit Weight Systems

Asbestos (British)	The number of 50 yard hanks per lb.
Asbestos (American Cut)	The number of 100 yard hanks per lb.
Cotton Count (British)	The number of 840 yard hanks per lb.
Cotton Count (Continental)	The number of 1,000 metre hanks per ½ kilogramme.
Spun Silk	The number of 840 yard hanks per lb.
Spun Rayon Staple Fibre	The number of 840 yard hanks per lb.
Linen Count (Wet Spun)	The number of 300 yard hanks or leas per lb.
Worsted Count	The number of 560 yard hanks per lb.
Woollen Count (Yorkshire Skeins)	The number of 256 yard hanks per lb. or the number of yards per dram.
Woollen Count (Galashiels Cut)	The number of 300 yard cuts per 24 oz.
Woollen Count (Hawick)	The number of 300 yard cuts per 26 oz.
Woollen Count (West of England)	The number of snaps (320 yard hanks) per lb.
Woollen Count (Dewsbury) and Cotton Bump Yarn Count	The number of yards per oz.
Woollen Count (Alloa)	The number of 11,520 yard spindles per 24 lb.
Woollen Count (American Cut)	The number of 300 yard hanks per lb.
Woollen Count (American Run)	The number of 100 yard hanks per oz.
Silk Count	The number of 1,000 yard hanks per oz.
Metric Count (applicable to all yarns)	The number of kilometre hanks per kilogramme or the number of 496 yard hanks per lb.
Typp[*]	The number of 1,000 yard hanks per lb.

Weight per Unit Length Systems

Denier	The weight in grammes of 9,000 metres of yarn.
Linen (Dry Spun) Hemp and Jute Count	The weight in lbs. of a spyndle of 14,400 yards of yarn.
Silk Count	The weight in drams of a hank of 1,000 yards.
Woollen Count (Aberdeen)	The weight in lbs. of 14,400 yards of yarn.
Woollen Count (American Grain)	The weight in grains of 20 yards of yarn.

Conversion

Within either system conversion from one count to another is done by means of multiplying factors. For example—

$$\text{Worsted Count} = 1{\cdot}5 \times \text{Cotton Count}$$
$$\text{and Cotton Count} = 0{\cdot}667 \times \text{Worsted Count}$$

These factors can be conveniently arranged in tabular form.

Table I gives the multiplying factors for converting from any one to any other of the length per unit weight systems.

Table II gives the multiplying factors for converting from any one to any other of the weight per unit length systems.

For conversion from the length per unit weight systems to the weight per unit

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[*] *From the initial letters of "Thousands of Yards Per Pound".*

Table I

Known Count in	Multiplying Factors to give Equivalent Count in									
	Cotton and Spun Silk	Worsted	Linen (Wet Spun)	Woollen (Yorkshire Skeins)	Woollen (West of England)	Woollen (Galashiels Cut)	Woollen (Hawick)	Woollen (Alloa)	Metric Count	Typp
Cotton and Spun Silk ...	1	1·5000	2·8000	3·2813	2·6250	4·2000	4·5500	1·7500	1·6934	0·8400
Worsted	0·6667	1	1·8667	2·1875	1·7500	2·8000	3·0333	1·1667	1·1289	0·5600
Linen (Wet Spun)	0·3571	0·5357	1	1·1719	0·9375	1·5000	1·6250	0·6250	0·6048	0·3000
Woollen (Yorkshire Skeins) ...	0·3048	0·4571	0·8533	1	0·8000	1·2800	1·3867	0·5333	0·5161	0·2560
Woollen (West of England) ...	0·3810	0·5714	1·0667	1·2500	1	1·6000	1·7333	0·6667	0·6449	0·3200
Woollen (Galashiels Cut) ...	0·2381	0·3571	0·6667	0·7813	0·6250	1	1·0833	0·4167	0·4032	0·2000
Woollen (Hawick)	0·2198	0·3297	0·6153	0·7211	0·5769	0·9230	1	0·3846	0·3721	0·1846
Woollen (Alloa)	0·5714	0·8571	1·6000	1·8750	1·5000	2·4000	2·6001	1	0·9676	0·4800
Metric	0·5905	0·8859	1·6535	1·9377	1·5502	2·4802	2·6870	1·0334	1	0·4961
Typp	1·1906	1·7857	3·3333	3·9061	3·1250	5·0000	5·4167	2·0833	2·0159	1

EXAMPLE—The equivalent of woollen count (Galashiels cut) 24 in woollen (West of England count) is 24 × 0·6250 or 15 length systems, constants into which the known counts are divided are necessary. For example, Cotton Count × Denier = 5315 and the denier corresponding to a known cotton count is given on dividing 5315 by the cotton count.

These constants are set out in Table III.

For the conversions from the British systems to the Continental systems and *vice versa* the following equivalents are used—

1 metre = 39·370 inches   1 yard = 0·9144 metres
1 kilogramme = 2·2046 lb.   1 lb. = 453·592 grams.

Table II

Known Count in	Multiplying Factor to give Count in			
	Denier	Linen (Dry Spun) or Woollen (Aberdeen)	Silk (Dram)	Woollen (American Grain)
Denier	1	0·003225	0·05734	0·03136
Linen (Dry Spun) or Woollen (Aberdeen)	310·0	1	17·78	9·722
Silk (Dram)	17·44	0·05625	1	0·5469
Woollen (American Grain) ...	31·89	0·1029	1·829	1

Example—The equivalent of silk (dram) count 80 in denier is 80 × 17·44 or 1395·2.

Table III

	Denier	Silk (Dram)	Linen (Dry Spun) or Woollen (Aberdeen)	Woollen (American Grain)
Cotton	5,315	304·8	17·14	166·7
Worsted	7,972	457·2	25·71	250·0
Linen (Wet Spun)	14,880	853·3	48·00	466·7
Woollen (Yorkshire Skeins) ...	17,430	1000	56·25	546·9
Woollen (West of England) ...	13,950	800·0	45·00	437·5
Woollen (Galashiels Cut) ...	22,320	1280	72·00	700·0
Woollen (Hawick)	24,180	1386	78·00	758·4
Woollen (Alloa)	9,301	533·3	30·00	291·7
Metric	9,000	516·1	29·03	282·2
Typp	4,464	256·0	14·40	140·0

Examples—The equivalent of worsted count 40 in denier is 7972 ÷ 40 or 199·3
The equivalent of silk (dram) count 50 in woollen (Yorkshire skeins) count is 1000 ÷ 50 or 20

ACCOUNTS FOR YEAR ENDED 31st DECEMBER 1939

At the meeting of the Representative Advisory Committee Executive on the 4th April, 1940, the accounts for the Textile Institute Scheme for Standardisation in Textiles were considered. The Executive recommended them for adoption by the Representative Advisory Committee.

The Representative Advisory Committee met on 13th June, 1940, when the accounts, as shown on Page S20, were received and instructions were given for their publication.

Standardisation in Textiles.

Revenue Account for the Year ended 31st December, 1939.

1938 £	s.	d.	EXPENSES.	£	s.	d.
36	0	0	To Rent and Rates	40	0	0
177	14	4	,, Salaries, Wages and Honoraria	275	8	4
46	4	11	,, Printing, Stationery and Publications ...	98	1	4
28	2	9	,, Meetings Expenses	3	2	5
21	10	1	,, Postages and Telephones	9	17	10
92	19	10	,, Travelling Expenses	62	2	8
8	3	0	,, Translations	–	–	–
–	–	–	,, Audit and Bank Charges	2	10	9
45	5	0	,, Equipment	–	–	–
–	–	–	,, Income Tax	25	0	0
10	15	0	,, Heating, Lighting and Cleaning	15	0	0
466	14	11		531	3	4
205	0	1	,, Surplus for Year	30	11	8
£671	15	0		£561	15	0

1938 £	s.	d.	RECEIPTS.	£	s.	d.	£	s.	d.
			By Subscriptions :—						
421	15	0	Organisations and Firms ...	361	15	0			
200	0	0	Textile Institute	50	0	0			
50	0	0	British Standards Institution	150	0	0			
							561	15	0
£671	15	0					£561	15	0

Balance Sheet as on 31st December, 1939.

1938 £	s.	d.	LIABILITIES.				£	s.	d.
			Sundry Creditors—						
18	9	5	Textile Institute—General Account ...				171	11	3
–	–	–	Accrued liabilities				25	6	6
			Revenue Account :—						
–	–	–	Balance as on 31st December, 1938...	£205	0	1			
205	0	1	*Add* Surplus for Year 1939 ...	30	11	8			
							235	11	9
£223	9	6					£432	9	6

1938 £	s.	d.	ASSETS.	£	s.	d.
223	9	6	Cash at Bank	377	4	6
			Sundry Debtors :—			
–	–	–	Outstanding Subscriptions	55	5	0
£223	9	6		£432	9	6

37, York Street, Manchester, 1,
1st April, 1940.

Audited and found Correct,
ARTHUR E. PIGGOTT, SON & CO.
Chartered Accountants, Auditors.

THE
Journal of the Textile Institute

VOL. XXXI—1940

STANDARDISATION INDEX

PAGE

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TRANSACTIONS AND INDEX

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TRANSACTIONS

1—MODIFIED STARCHES. Part III.

DEGRADATION OF STARCHES BY ACIDIC AND ALKALINE OXIDISING AGENTS, ACIDS, Etc.

By G. B. Jambuserwala and K. R. Kanitkar.

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In continuation of the work published in this *Journal* as Parts I* and II**, the authors have degraded starches by means of (*a*) mixtures of potassium dichromate and sulphuric acid, using six different concentrations of the acid, the quantity of potassium dichromate, and therefore of available oxygen, being kept constant in all the six cases; (*b*) sulphuric acid alone of the same concentrations as in (*a*), and (*c*) alkaline hypochlorite solutions. Broadly speaking an exhaustive study of the properties of the modified starches produced in the present investigation has been made on the lines of Part II**, and in addition determinations of the "binding values" of these products have been made. Further, the chemical and textile qualities of these products have been compared and correlated with some of the commercial "thin boiling" starches like Penetrose, Textiline and Fabricollin.

Acidic, enzymic and bacterial hydrolysis result in the production of glucose or maltose as the ultimate products. By controlling the conditions a number of intermediate starch products and dextrins have been produced. Kirchhoff (*Acad. Imp. Sci.*, St. Petersburg, 1811, **4**, 27) was the first to observe that acid converted starch into glucose. This classical discovery was commercialised in Germany in 1812, and subsequently in America by Guthrie (1831). Further, Breyer (U.S.P.881,104; 881,105 of 1905) employed a similar process, but used a weaker acid for a longer time. Duryea (U.S.P.675,822 of 1901; 696,949 of 1902) developed processes for preparing thin boiling starches by drying slightly acidulated starch at elevated temperatures. Bechamp (*Compt. rend.*, 1854, **39**, 653) studied the action of nitric, sulphuric and acetic acids on starch and obtained products that were soluble in cold water. Blondeau (*Ann. de chim. et de Physique*, 1863(3), **68**, 468), treated starch with sulphuric acid to produce soluble starch. F. Baeyer and Co. (Fr.P.383,902 of 1907) treated starch with a small quantity of mineral acid in the presence of acetic acid, the starch was thus rendered soluble in hot water. Welwart (*Chem. Zeit.*, 1907, **31**, 126) converted starch by boiling with a little formic acid and then boiling off the acid.

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* Jambuserwala, *J. Text. Inst.*, 1938, **29**, T149.
** Jambuserwala and Kanitkar, *J. Text. Inst.*, 1939, **30**, T85.

Hertwig (U.S.P.798,509 of 1905) and Mac-Millan (U.S.P.1,582,537) treated starch with gaseous chlorine for a number of days at the ordinary temperature to obtain a product soluble in water. Rassow (*Textilber.*, 1931, **12,** 468) treated starch with a sodium hypochlorite solution to render it soluble. Montgomerie (B.P.490,070) obtained a product useful for sizing paper and dressing fabric by treatment with hypochlorite solutions at 130-160° F. Fuller (B.P.383,778) treated raw starch with an aqueous bleaching powder solution to obtain starch with modified properties.

The observation that starch and starch products exhibit remarkable reducing properties was made but recently by Fargher and Probert (*J. Text. Inst.*, 1927, **18,** T559). Degraded starches have reducing values which may be taken to measure quantitatively the aldehydic groups formed as a result of modification and the end reducing groups. Richardson (*Chem. and Ind.*, 1939, **58,** 464) has contended that for starch modified by means of acid the reducing power affords an accurate measure of the extent of modification. The reducing power, however, cannot be regarded generally as a property peculiar to soluble starches, since the relation between reducing power and extent of modification varies with the method of modification. The source of reducing power in starches modified by oxidation is not very clear. The reducing powers of starches modified by oxidation are considerably lower than those modified to the same extent by acids. In such cases, viscosity measurements afford a far more accurate estimate of the chemical degradation of the starches.

The alkali-labile material in starch is of a reducing character and can be estimated by the well-known hypoiodite method (Willstäter and Schudel, *Ber.*, 1918, **51**. 780 ; *Analyst*, 1918, **43,** 416) subsequently standardised by Hinton and Macara (*Analyst*, 1924, **49,** 2) for estimating quantitatively reducing sugars like glucose. The original procedure entailed the use of caustic soda, and therefore it was suggested that weaker alkalis such as sodium carbonate, borax, etc., could be used, digestion being continued for a longer time at higher temperatures and concentrations. Taylor and Salzmann (*J. Am. Chem. Soc.*, 1933, **55,** 264) adopted a similar procedure for starch products, first digesting starch with dilute alkali, then neutralising and determining the reducing matter iodometrically. The earlier method for the determination of alkali-labile value was carefully standardised by Taylor (*J. Ind. Eng. Chem. Anal. Ed.*, 1935, **7,** 321). The advantage of the estimation of alkali-labile value over the estimation of reducing value is mainly in the case of slightly degraded products, which exhibit small differences in reducing value.

M. Samec (*Koll. Chem. Beihefte*, 1929, **28,** 155) pointed out that the electrical conductivity of soluble starches prepared by oxidation is about ten times that of the untreated starch. This high conductivity together with the potentiometrically active hydrogen ions and the alkali-binding capacity indicated that during oxidation some acid groups are introduced. Katz (*Text. Res.*, 1938-39, **9,** 146) similarly considered that carboxyl groups are introduced into starch on treatment with hypochlorite solutions. The modified method of Neale and Stringfellow (*Trans. Faraday Soc.*, 1937, **33,** 881) was employed in the present investigation to evaluate carboxyl groups present in the modified starches.

The internal friction in certain solutions giving rise to the phenomenon of viscosity or resistance to flow may be partly ascribed to the presence of large particles or molecular aggregates. This applies to starch solutions which, being colloidal, exhibit considerable viscosity. Starch, unlike cellulose, is very sensitive to chemical action, and the changes in viscosity of the paste due to chemical modification are very pronounced. This fall in viscosity can be regarded in two ways. The structure of starch granules may be considered as consisting of amylose distributed in a net-work of amylopectin, the whole granule on pasting forming a sort of a " sac " and producing a viscous mass. On modification this sac is ruptured giving a lower viscosity (Katz, *J. Text. Res.*, 1938-39, **9**, 146 ; and Sojstron, *J. Ind. Eng. Chem.*, 1936, **26**, 63). In the second view the long glucosidic rings are disrupted on modification to give shorter chains and a reduction in the viscosity of the pastes. Also Katz (loc. cit.) has observed that the viscosity of starch pastes decreases on continuous boiling and agitation owing to the rupture of the cell walls, and a minimum constant consistency is obtained only after more than two hours of cooking. Caesar (*J. Ind. Eng. Chem.*, 1932, **24**, 1432) pointed out the importance of the concentration at which the viscosity of the starch pastes is measured and considers that concentrations not exceeding 3% would alone give reliable results. Recently, Katz, Desai and Seiberlich (*Trans. Faraday Soc.*, 1938, **34**, 1258) have investigated the influence of concentration and rate of stirring on the viscosity of 1% starch paste. Galley and Bell (*Canadian J. Res.*, 1936, **14B**, 360) determined the viscosity of soluble starches in 1% caustic soda solution and estimated the extent of chemical degradation from the viscosity measurements. Staudinger and Husemann (*Ann.*, 1937, **530**, 195) have also regarded viscosity as a measure of chemical degradation. Richardson (*Chem. and Ind.*, 1939, **58**, 464) found 30% aqueous calcium thiocyanate solution the most satisfactory solvent for starches and he measured the relative viscosity of 1% starch in this solvent by means of a capillary U-tube. He has contended that the reducing power of modified starches cannot be used generally as a measure of chemical change, but " thiocyanate viscosity " would give a good estimate of chemical degradation especially in the case of oxidised starches when the origin of reducing power is not very clear.

The chief ingredients of a size mixture are starch and china clay. When a fibre is sized with a size mixture, starch helps the fibre to take up a certain proportion of china clay. The latter is as if it were bound up with the aid of the starch to the fibre and this ability of starch to take up china clay is its specific property, known as its " binding value." Binding value varies considerably from starch to starch and on modification starch suffers heavily in this respect. It is usual, in the analysis of a size to obtain the percentage of starch present on the fibre by difference between the quantities of total size and the sum of all other ingredients. The methods for the determination of mineral matters suggested by Bean and Scaresbrick (*Chemistry and Practice of Sizing*, 10th Ed., p. 596) and Ermen (*Materials Used in Sizing*, p. 82), have been adversely criticised by Smith (*J. Text. Inst.*, 1928, **19**, T323). He formulated a method for the direct estimation of china clay in sized goods. The last method was adopted in the present investigation to note definitely the extent to which degraded starches suffered in their binding properties.

EXPERIMENTAL

Modification of Starches

(*a*) *Potassium dichromate and sulphuric acid mixtures.* Samples of 100 g. each of dried corn, farina, sago and wheat starches were treated separately with 400 c.c. of oxidising mixtures of the following six concentrations:—

1. 0·2% potassium dichromate and 0·5 *N* sulphuric acid.
2. 0·2% ,, ,, 0·4 *N* ,, ,,
3. 0·2% ,, ,, 0·3 *N* ,, ,,
4. 0·2% ,, ,, 0·2 *N* ,, ,,
5. 0·2% ,, ,, 0·1 *N* ,, ,,
6. 0·2% ,, ,, 0·05 *N* ,, ,,

The mixtures were added to the flask containing the weighed starch gradually, with vigorous shaking and without allowing the temperature to rise. The digestion was continued for twenty hours and the starch was then filtered off and washed free from acid. It may be noted that in the 6th mixture the quantity of acid used, was just sufficient to liberate the total available oxygen from the dichromate used, whilst there was an excess of the acid in the other five cases. The available oxygen in each of the six cases was 0·13 g. per 100 g. of starch. In this manner 24 products were obtained, sufficient in quantity for the purpose of the present investigation.

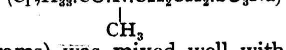
(*b*) *Sulphuric acid.* In method (*a*) starches were modified by six oxidising mixtures of potassium dichromate and sulphuric acid, altering the concentration of the acid alone. To study the hydrolytic effect of the acid, corn starch was treated with 0·5 *N* ; 0·4 *N* ; 0·3 *N* ; 0·2 *N* ; 0·1 *N* and 0·05 *N* concentrations of sulphuric acid as directed in the method (*a*) above.

(*c*) *Alkaline hypochlorite solutions.* A study has already been made of the effect of neutral hypochlorite solutions on different starches, and in this part of the work the effects of alkaline hypochlorite solutions on corn starch have been studied.

Samples of 50 g. of dried corn starch were treated with 100 c.c. of neutral hypochlorite solutions containing 1%, 2% and 3% of free available chlorine on the weight of starch and to which 1 c.c. of ammonia (sp. gr. 0·88) was added. The treatment was confined to 20 hours at room temperature and was finished up as in method (*a*) above.

(*d*) *Sulphurous acid.* In order to compare the effects of a reducing agent on starches, corn starch (50 grams) was treated with 200 c.c of solutions containing 10% and 2% sulphurous acid (on the weight of starch), retaining the same conditions of temperature and period of digestion, etc., as in the previous experiments.

(*e*) *Mixing with wetting agents.* Seck (*Melliand Textilber.*, 1936, **17**, 146 ; 343 ; 506) has stated that the viscosity of a starch paste depends upon the degree of dispersion of the starch granules in its solution. Starch was therefore mixed with two well-known wetting agents, viz., Nekal BX (sodium salt of alkylated naphthalene sulphonic acid) and Igepon T



$$(C_{17}H_{33}.CO.\underset{\displaystyle CH_3}{\underset{|}{N}}.CH_2CH_2.SO_3Na)$$

The corn starch (100 grams) was mixed well with 1 g. of Nekal BX and Igepon T separately in a small porcelain ball mill for two hours in the dry state. The two mixtures so obtained were tested for their viscosity only, since no chemical degradation takes place on mixing starch with the dispersing agents.

Reducing Values

Reducing values for the modified starches produced by the different methods, were determined as described in Part II of the authors' paper, and the results thereof are set out in Table I, Column 2. The sulphurous acid modifications and the commerical varieties do not exhibit any great reducing properties.

Alkali-labile Values

These were determined on the lines indicated in the previous communication, and the results are set out in Table I, Column 3. The ammoniacal hypochlorite treated products indicate very small increase in alkali-labile values.

Carboxyl Groups

These determinations were made as detailed in Part II and the results so obtained are set out in Table I, Column 4. The carboxyl group contents of products obtained by methods (*b*) and (*d*), are very low because of the absence of an oxidising agent. Low content of carboxyl groups is found in the commercial products and therefore it may be contended that they may not have been produced by means of oxidising agents. And it will be observed in Fig. V, that no possible relation could be drawn between carboxyl groups and alkali-labile values of the presently modified starches.

Starch-iodide Tints

The progress in the degradation of starch is estimated by changes in the starch-iodide colour, using a Lovibond tintometer to express starch-iodide colour tints in numerical units, as described in the earlier paper. With increase in degree of modification, the red units increase and the blue units decrease and the difference between these two (blue minus red) would include the changes in either of the colours which may be conveniently called the "resultant colour unit." This resultant colour unit decreases with increase in the degree of modification. The results are set out in Table I, Columns 5, 6 and 7. The starch-iodide tints of the commerical products are predominantly blue and the red units are very low.

Viscosity Measurements

As previously described the viscosity measurements of the modified starches were made by means of a Höppler viscosimeter using 2·5% and 1% starch pastes at 70° C. and 30° C. The results of these determinations are set out in Table II, Columns 2, 3 and 4. The fall in viscosity of the modified forms produced by methods (*b*), (*c*) and (*d*) is not so marked as of those produced by the method (*a*), whereas corn starch admixed with Nekal BX and Igepon T (method (*e*)) gave nearly half its initial viscosity indicating that the dispersing agents helped to lower the consistency of starch pastes.

Herbig Numbers

In order to evaluate the penetrating properties of the starches, their Herbig numbers were determined by means of a Herbig tester as detailed in Part II. The Herbig numbers so obtained were converted into "penetrating units," which, as suggested in the previous paper, give comparable estimates of the penetrating properties of the starches. The Herbig numbers and "penetrating units" are set out in Table II, Columns 5 and 6 respectively. It may be observed that modified products obtained in this investigation are much superior to commercial products in their penetrating properties.

Table I

Starch.	Method of modifying.	R_{Cu} in mgm. per g. of starch estimated by cerium sulphate.	Alkali-labile values in mg. of iodine per 100 g. starch.	Carboxyl groups in milli-equivalents per 100 g. starch.	Starch-iodide tints.		
					Units of Blue.	Units of Red.	Units of "Resultant Colour" (Blue-Red).
	1	2	3	4	5	6	7
	Potassium Dichromate and Sulphuric Acid.					*	
Corn	*Method* (a)	5·80	16·8	1·80	16·6	0·5	16·1
,, ...	1	40·7	33·1	3·25	15·1	3·5	11·6
,, ...	2	38·6	—	—	15·40	3·1	12·3
,, ...	3	36·5	31·1	2·95	15·7	2·6	13·1
,, ...	4	33·8	—	—	15·8	2·0	13·8
,, ...	5	30·0	30·8	2·34	16·2	1·9	14·3
,, ...	6	25·5	28·9	2·03	16·4	1·6	14·8
Farina... ...	—	8·9	18·60	2·65	16·9	0·0	16·9
,, ...	1	94·2	39·05	4·47	15·6	1·1	14·5
,, ...	2	76·8	35·5	4·06	15·7	0·9	14·8
,, ...	3	65·9	—	—	16·0	0·7	15·3
,, ...	4	54·5	—	—	16·4	0·6	15·8
,, ...	5	39·2	33·6	3·45	16·5	0·6	15·9
,, ...	6	26·3	30·9	3·25	16·6	0·3	16·3
Sago	—	8·3	18·7	1·90	16·3	0·3	16·0
,, ...	1	59·1	33·8	3·38	15·3	0·0	15·3
,, ...	2	55·7	—	—	15·4	0·0	15·4
,, ...	3	43·7	30·9	2·91	15·6	0·0	15·6
,, ...	4	39·7	—	—	—	—	—
,, ...	5	31·3	29·6	2·64	15·9	0·0	15·9
,, ...	6	25·03	29·3	2·44	16·1	0·0	16·1
Wheat... ...	—	8·54	22·6	1·2	16·7	0·3	16·4
,, ...	1	42·5	35·4	3·82	14·7	2·8	11·9
,, ...	2	40·4	—	—	15·2	2·3	12·9
,, ...	3	37·5	33·1	3·15	15·8	1·7	14·1
,, ...	4	33·2	—	—	15·8	1·5	14·3
,, ...	5	29·1	31·9	2·64	15·9	1·2	14·7
,, ...	6	27·7	29·7	2·44	16·1	0·9	15·2
	Method (b) Sulphuric Acid						
Corn	0·5*N*	8·04	—	1·80	—	—	—
,, ...	0·4*N*	5·95	—	—	—	—	—
,, ...	0·3*N*	5·60	—	—	—	—	—
,, ...	0·2*N*	4·80	—	—	—	—	—
,, ...	0·1*N*	4·40	—	—	—	—	—
,, ...	0·05*N*	—	—	—	*	—	—
	Method (c) Chlorine Ammonia						
Corn	1% + 1 c.c.	6·10	16·3	1·8	—	—	—
,, ...	2% + 1 c.c.	9·90	19·5	1·9	—	—	—
,, ...	3% + 1 c.c.	17·9	22·2	2·8	—	—	—
	Method (d) Sulphurous Acid						
Corn	10%	8·9	—	—	—	—	—
,, ...	2%	6·1	—	1·6	—	—	—
Penetrose I ...	—	9·7	27·9	2.11	15·9	1·6	14·3
,, III ...	—	2·7	26·0	1·9	16·1	1·0	15·1
Textiline WI ...	—	Negligible	22·3	2·54	17·0	0·0	17·0
Fabricollin ...	—	3·5	16·5	2·22	17·0	0·0	17·0

* Units of yellow were maintained at about 2·2.

Table II

Starch.	Methods of modifying.	Viscosity in centipoises.			Herbig numbers.	"Penetrating units"	Drop numbers.
		2·5% paste. 30° C.	2·5% paste. 70° C.	1% paste. 70° C.			
	1	2	3	4 *	5 †	6 ‡	7
	Potassium Dichromate and Sulphuric Acid.						
Corn	*Method* (a)	8·88	4·36	0·85	45·8	21·3	192
,, ...	1	1·40	0·72	0·55	28·5	23·0	214
,, ...	2	1·5	0·72	0·55	—	—	—
,, ...	3	1·51	0·73	0·60	—	—	—
,, ...	4	1·58	0·77	0·63	35·9	22·6	202
,, ...	5	1·71	0·82	—	—	—	—
,, ...	6	2·05	1·04	0·64	—	—	—
Farina ...	—	6·07	2·94	1·24	42·4	13·4	170
,, ...	1	1·33	0·68	0·48	24·0	18·1	184
,, ...	2	1·47	0·71	0·49	—	—	—
,, ...	3	1·63	0·79	—	—	—	—
,, ...	4	1·64	0·80	0·55	27·6	18·4	179
,, ...	5	1·65	0·81	0·58	—	—	—
,, ...	6	1·84	0·93	0·59	—	—	—
Sago	—	5·19	2·52	0·90	33·2	13·3	168
,, ...	1	1·62	0·79	0·59	24·4	17·6	182
,, ...	2	1·70	0·80	0·60	—	—	—
,, ...	3	1·70	0·85	0·61	—	—	—
,, ...	4	1·75	0·87	0·612	25·3	16·5	176
,, ...	5	1·80	0·92	0·62	—	—	—
,, ...	6	1·85	0·94	0·63	—	—	—
Wheat ...	—	3·54	1·68	0·76	39·3	21·0	212
,, ...	1	1·45	0·69	0·55	24·8	22·2	234
,, ...	2	1·50	0·70	0·57	—	—	—
,, ...	3	1·56	0·76	0·573	—	—	—
,, ...	4	1·64	0·77	—	—	—	—
,, ...	5	1·74	0·80	0·58	29·5	21·6	225
,, ...	6	1·79	0·84	0·59	—	—	—
	Method (b) Sulphuric Acid.						
Corn	0·5*N*	3·56	1·82	—	—	—	—
,, ...	0·4*N*	4·35	2·34	—	—	—	—
,, ...	0·3*N*	4·50	2·34	—	—	—	—
,, ...	0·2*N*	5·81	2·67	—	—	—	—
,, ...	0·1*N*	6·18	2·99	—	—	—	—
,, ...	0·05*N*	6·64	3·36	—	—	—	—
	Method (c) Chlorine Ammonia						
Corn	1% + 1 c.c.	2·81	1·27	—	—	—	—
,, ...	2% + 1 c.c.	2·15	1·07	—	—	—	—
,, ...	3% + 1 c.c.	1·98	0·99	—	—	—	—
	Method (d) Sulphurous Acid.						
Corn	10%	3·32	1·71	—	—	—	—
,, ...	2%	6·696	3·15	—	—	—	—
Penetrose I...	—	2·01	0·97	0·55	26·8	19·9	191
,, III ...	—	3·22	1·66	0·67	33·2	20·2	188
Textiline WI ...	—	5·29	2·49	0·85	34·1	15·97	183
Fabricollin ...	—	20·50	10·2	2·03	55·1	11·1	170
	Method (e)						
Corn	+ Igepon T	4·26	2·23	1·91	—	—	—
,, ...	+ Nekal BX	3·95	2·08	1·90	—	—	—

* η of water at 70°C. = 0·406.

† Herbig number of water at 70° C. = 40.

‡ Herbig number × $\eta_{70°C.}$ of water ÷ $\eta_{70°C.}$ starch paste = Penetrating unit

Table III

Starch.	Methods of modifying.	Percentage increase in weight of yarn by sizing.	Energy of Rupture in inch-lb.	Stiffness values in mg.		Adhesive values in grams.	Binding values g. of china-clay/ 1 g. starch.
				Yarn.	Filter paper.		
	1	2	3	4	5	6	7
	Potassium Dichromate and Sulphuric Acid.	*	†	‡	§		
Corn	*Method* (a)	14·7	26·0	1,246	516	31·6	3·0
,, ...	1	9·0	27·0	961	382	10·6	2·2
,, ...	2	9·2	26·6	961	400	—	—
,, ...	3	—	26·4	—	—	—	—
,, ...	4	8·9	26·6	—	—	—	—
,, ...	5	9·3	26·7	997	—	—	—
,, ...	6	10·0	26·1	998	400	11·0	—
Farina ...	—	9·3	25·5	1,281	445	50·0	2·7
,, ...	1	8·0	26·1	908	382	8·2	1·7
,, ...	2	7·1	25·8	—	—	—	—
,, ...	3	—	25·7	—	—	—	—
,, ...	4	7·4	25·7	926	409	—	—
,, ...	5	—	26·3	1,015	—	—	—
,, ...	6	9·25	25·9	1,066	427	9·1	—
Sago	—	16·3	25·6	1,175	520	37·5	3·6
,, ...	1	9·5	28·9	961	391	10·1	1·3
,, ...	2	8·7	27·9	—	—	—	—
,, ...	3	8·4	27·3	997	291	—	—
,, ...	4	8·7	26·6	—	—	—	—
,, ...	5	8·9	26·3	1,033	—	—	—
,, ...	6	9·5	26·3	1,066	409	10·7	—
Wheat ...	—	15·0	26·3	1,308	471	48·90	2·4
,, ...	1	9·7	27·9	926	391	9·5	2·0
,, ...	2	—	27·7	—	—	—	—
,, ...	3	9·4	27·4	1,050	400	—	—
,, ...	4	9·0	27·2	—	—	—	—
,, ...	5	9·2	26·9	1,140	—	—	—
,, ...	6	9·8	26·4	1,174	427	11·0	—
Penetrose I ...	—	8·0	28·2	943	418	—	3·1
,, II ...	—	9·3	27·6	961	—	—	—
,, III ...	—	10·2	27·4	997	453	—	3·3
Textiline WI ...	—	7·0	25·4	—	498	—	3·3
Fabricollin ...	—	17·0	25·4	—	511	—	3·6

* Weight of yarn sized about 25 g.

† Energy of Rupture of unsized yarn (1/2 lea) 24 inch-lb.

‡ Stiffness values of untreated yarn 961 mg.

§ Stiffness values of untreated filter paper 226 mg.

Drop Numbers

The interfacial tensions between the starch pastes and petroleum (b.p. 130-140° C.) were measured by means of a Donnan pipette as described in the previous communication. Thus the number of drops of petroleum emitted from the pipette into a starch solution gave a measure of the wetting or the penetrating properties of the starch pastes under test. The results of these determinations are set out in Table II, Column 7, which indicate that the largest number of drops are emitted in case of wheat starch, followed by corn, sago and farina starch in the decreasing order of penetration.

Energy of Rupture of Sized Yarns

80's yarn (about 25 grams) was sized with 10% paste of each of the modified starches, and the yarn was dried and weighed. Subsequently tests on half leas were made by means of a ballistic tester as outlined in Part I and the results are set out in Table III, Columns 2 and 3. These results indicate that as the viscosity falls with the extent of modification of the starch, there is a reduced increase in the weight of yarn on sizing. It may be noted that the results of the increase in weight on sizing and the energy of rupture of sized yarn compare very favourably with those of commercial products (Table III, Columns 2 and 3).

Stiffness Values

Stiffness measurements of sized yarn and sized strips of filter paper were made out on a Gurley's stiffness tester as described in Parts I and II. The results are set out in Table III, Columns 4 and 5. There is a very regular fall in the stiffness of the yarns and papers sized with the mixtures containing starches modified by means of potassium dichromate and sulphuric acid. Therefore it is clear that modified starches impart a softer feel to the sized fibre, one of the reasons being that there is a smaller surface coating on the fibre.

Adhesive Values

The modified method of Saare was employed for determining the adhesive powers of the degraded starches as in Parts I and II and the results are recorded in Table III, Column 6. The results indicate that the modified starches exhibit a great reduction in adhesive value when modified by the lowest concentration of the oxidising mixture and that no further appreciable fall is observed as the concentration of the oxidising mixture increases.

Binding Value Determinations

The binding value of starch is estimated by sizing a textile material with a size of known composition containing starch and china clay and subsequently analysing the size on the fibre for the relative proportions of the two ingredients. It is well known that starch can hold only a certain maximum quantity of china clay and the excess that may be present on the fibre can be readily dusted off by mere shaking.

Starch (5 grams) was pasted with 150 c.c. of water and heated to 90-95° C. for 2 hours. It was then mixed with 100 c.c. of a suspension of 15 g. of dried china clay in water. This mixture was stirred mechanically in a round bottomed flask maintained at a temperature of 90° C. by means of a water bath for one hour. 20's yarn (25 grams) was sized with the 250 c.c. of the well-mixed size on a Kleineweifer mercerising machine. The sized yarn was dried and the percentage increase in weight was determined. The excess of china clay was dusted off by giving a fixed number of regular shakes to the sized yarn and subsequently determining the percentage of fixed size.

Part of the sized yarn (2 to 3 grams) was heated with 25 c.c. of hydrochloric acid (33%) for half an hour over a boiling water bath, till all the yarn was disintegrated. The residue was filtered off, dried and incinerated in weighed crucibles and heated to 900° C. for 2-3 hours in an electrical muffle furnace to constant weight. This gave the quantity of china clay present on the fibre, the ash of the cotton being negligible. The quantity of starch on the fibre was deduced by deducting the china clay content from the percentage increase in the weight of the yarn after sizing and dusting. From these figures the amount of china clay (in grams) taken up by 1 g. of starch was calculated. The results are recorded in Table III, Column 7. These indicate that the binding values of starch decrease with the degree of modification. In sizing, since the fibre picks up smaller quantities of sizes of low viscosity than it does of more viscous sizes, modified starches exhibit smaller power to bind mineral matters like china clay than raw starches. The binding values of the commercial products are not found to give higher values than untreated varieties.

Penetrose I, II and III, Textiline and Fabricollin are commercial thin boiling starches. The first three are produced from corn starch, whereas the other two are produced from farina starch. Penetrose I, II and III are manufactured by the Corn Products Refining Co. (U.S.A.), Textiline by the W. A. Scholten Chemische Fabrik, Groningen (Holland), and Fabricollin by the N. V. Chemische Fabrik Servo, Delden (Holland). These commercial preparations are extensively used in the Indian Textile Industry and hence the present study of their properties should furnish useful data.

DISCUSSION OF RESULTS

As observed in Parts I and II, when reducing values are taken as a measure of degradation in starches, it is found that the four varieties of starch are not affected to the same extent by the chromic acid mixtures. Farina suffers the greatest degradation, followed by sago, wheat and corn starches in the decreasing order. Curiously enough the order is the same as that of the granule sizes of the starches and it is possible that farina with the largest granules is most affected by the modifying agents. Modified forms obtained by hydrolysing with sulphuric acid alone do not exhibit as great reducing properties as products obtained by chromic acid mixtures, the latter being more reactive. It is also well known that oxidising mixtures convert the end groups of cellulose and carbohydrates into ketonic groups and then into carboxyl groups, the rate and extent depending upon the concentration and nature of the reagent. Further, Clibbens and Ridge (*J. Text. Inst.*, 1927, **18**, T135) have made it clear that oxidising agents are more reactive to cellulose in presence of acids. It has been found that the reducing values of starches modified by means of alkaline hypochlorite are about one half of those of products produced by neutral hypochlorite solutions (Part II). This confirms the work of Britwell, Clibbens and Ridge (*J. Text. Inst.*, 1923, **14**, T297) on cellulose, for which the copper number increased with the decreasing alkalinity of the hypochlorite solution. However, though products degraded by means of chromic acid give higher reducing values as compared with neutral hypochlorite products, the former have comparatively lower viscosities, alkali-labile values, starch-iodide tints, etc. Therefore it may be pointed out that as suggested by Richardson (*Chem. and Ind.*, 1939, **58**, 464) the reducing values of modified starches cannot be reckoned as a true measure of the degree of degradation in all cases, particularly the oxidised products. In any case the reducing values of degraded starches can be safely taken to measure quantitatively the aldehydic and reducing groups introduced into starches on modification.

The maximum increase in alkali-labile value shown by the four varieties of starches after modification by means of chromic acid is only 5, while the reducing values increase by 15, 15, 50 and 68 in case of corn, wheat, sago and farina starch respectively. Also it will be observed that the alkali-labile values of untreated starches are three times as great as their reducing values, but the most degraded forms produced by the chromic acid mixture exhibit lower alkali-labile values than reducing values. Therefore it appears that on modifying starches the increase in reducing groups and the increase in the alkali-labile part are not identical. It is possible that on degradation reducing groups that are introduced are not labile to caustic soda of 0·1 *N* concentration and hence the comparatively smaller increase in alkali-labile values. However the subject requires further elucidation, for it is difficult to explain why the results of the two tests do not run parallel courses for the raw and modified starches when each test determines the reducing properties of starches. It would be safe to point out that, as the name suggests, alkali-labile values give an indication only of the quantity of alkali-labile portion present and do not indicate the real reducing power of the starch.

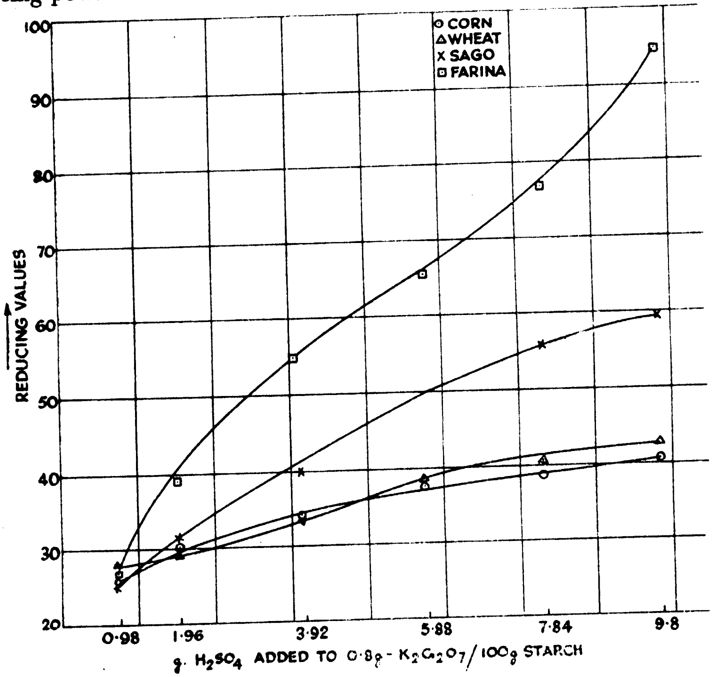
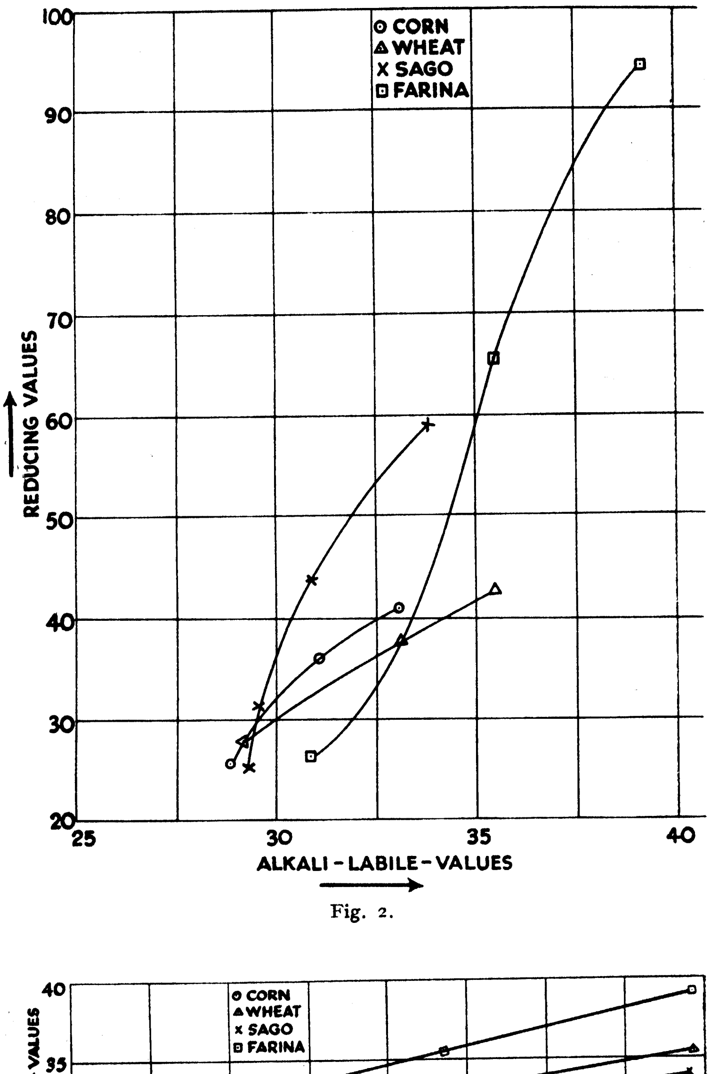


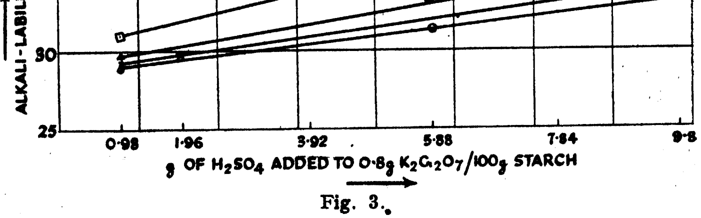
Fig. 1.

The carboxyl group contents of starches modified by means of chromic acid do not exhibit an appreciable increase because they are effected by the increasing quantities of acid used with the fixed amount of potassium dichromate. As the amount of oxygen liberated is the same in each case the oxidative action is limited. The modified products produced by the action of alkaline hypochlorite solutions do not contain as many carboxyl groups as those obtained by treatment with neutral hypochlorite solutions. Sulphuric acid and sulphurous acid treated products, as one would expect, have a limited number of carboxyl groups because of the absence of oxygen-giving reagents. Thus, from the study of the chemical properties of the degraded starches, it may be concluded that starch and cellulose, which have closely related chemical constitution, react with acid, oxidising agents, etc., more or less identically. Starch being less inert than cellulose, it is



○ CORN
△ WHEAT
X SAGO
□ FARINA
100
90
80
70
60
50
40
30
20
REDUCING VALUES
25
30
35
40
ALKALI - LABILE - VALUES

Fig. 2.



○ CORN
△ WHEAT
× SAGO
□ FARINA
40
35
30
25
ALKALI - LABILE - VALUES
0·98
1·96
3·92
5·88
7·84
9·8
g OF H_2SO_4 ADDED TO 0·8g $K_2Cr_2O_7$/100g STARCH

Fig. 3.

more readily attacked by the reagents, though the degraded products have similar properties. Very little is known about the chemical nature of the degraded products of starch and this defect may be remedied when more light is thrown on the constitution of carbohydrates.

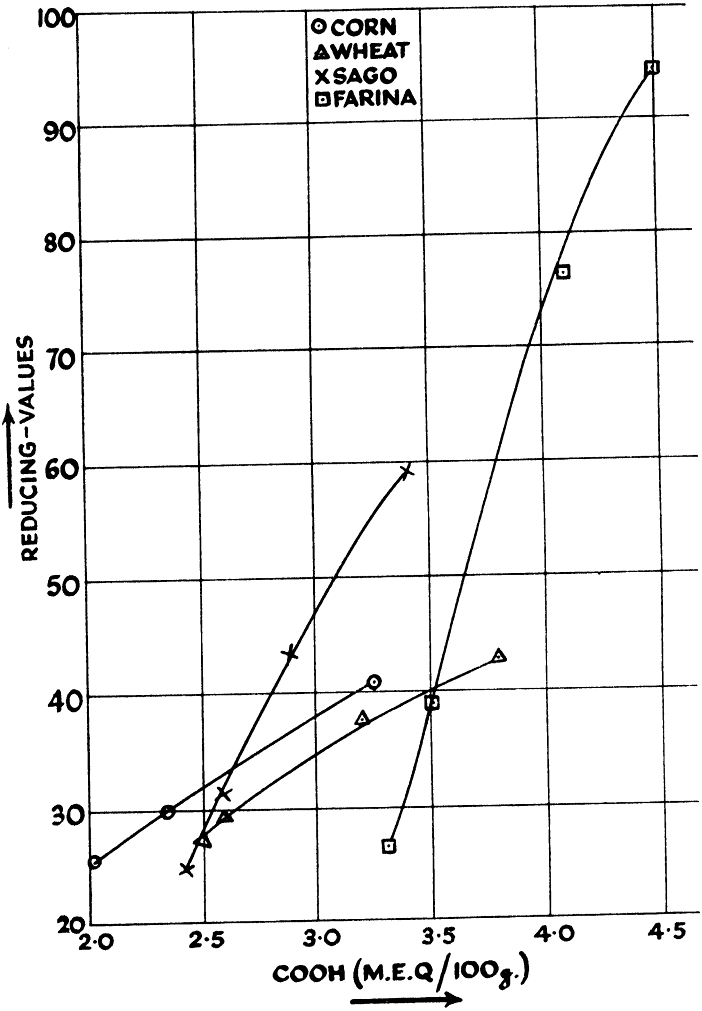


Fig. 4.

Table II, Columns 2, 3 and 4, point out that there is a sharp initial fall in the viscosity of starches on modification, which may be attributed to (*a*) the rupture of the amylopection network that surrounds the amylose by the action of a modifying agent and the consequent inability of starch granules to swell ; and (*b*) the complex starch molecule is chemically degraded to simpler shorter chains, causing a reduction in viscosity.

It is observed in Table II, Columns 4, 6 and 7, that with the decrease in the viscosity of starch pastes penetrating properties increase. This is borne out both by the " Penetrating units " and the " Drop numbers." Further the results reveal that wheat starch has the greatest penetrating power, followed by corn, sago and farina in decreasing order of penetration.

Modified starches, being less viscous, produce lighter coatings on the surface of the fibre, though the quantity of starch penetrated may be greater. Hence what is gained by penetration by way of increase in energy of rupture on sizing with modified starches, is partially lost by the thinner surface coating on the fibre. However, compared on the basis of increase in energy of rupture of yarn per unit increase in weight of yarn on sizing, the modified starches are found to give greater energy of rupture to the sized yarn than the untreated varieties.

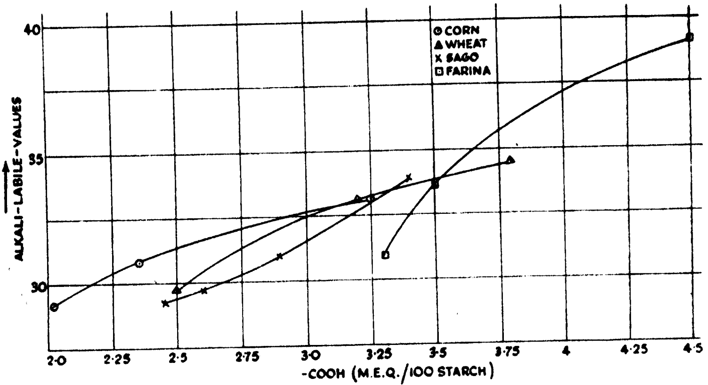


Fig. 5.

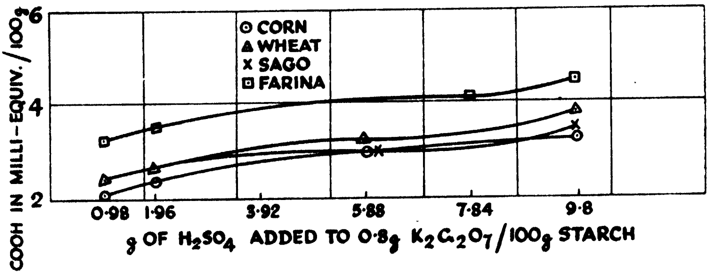


Fig. 6.

Alkali-labile values, carboxyl group contents, starch-iodide tints and time of fall of the ball in the viscosity test increase almost linearly with increase in the concentrations of the acid in the oxidising mixtures as indicated in Figs. III, VI, VIII, and IX respectively. Therefore, it may be concluded that only a gradual chemical degradation takes place in all the four varieties of starches. Reducing values plotted against the concentrations of sulphuric acid in chromic acid mixtures do not give a straight line relation (Fig. I), because the degradative action on starches is due to both oxidising and hydrolysing action, the latter of which is varying from stage to stage.

There is a smooth relation between the reducing values and alkali-labile values, carboxyl group contents and viscosity of the four varieties of starches as graphically represented by Figs. II, IV and VII respectively.

It is observed in Table I, Column 7, that certain modified starches degraded by chromic acid mixtures gave higher "Resultant Colour" units than those produced by means of hypochlorite solutions, though in corresponding cases reducing values are nearly equal. Therefore it may be contended that the chemical and physical changes taking place in starches by the two methods of degradation are of different nature.

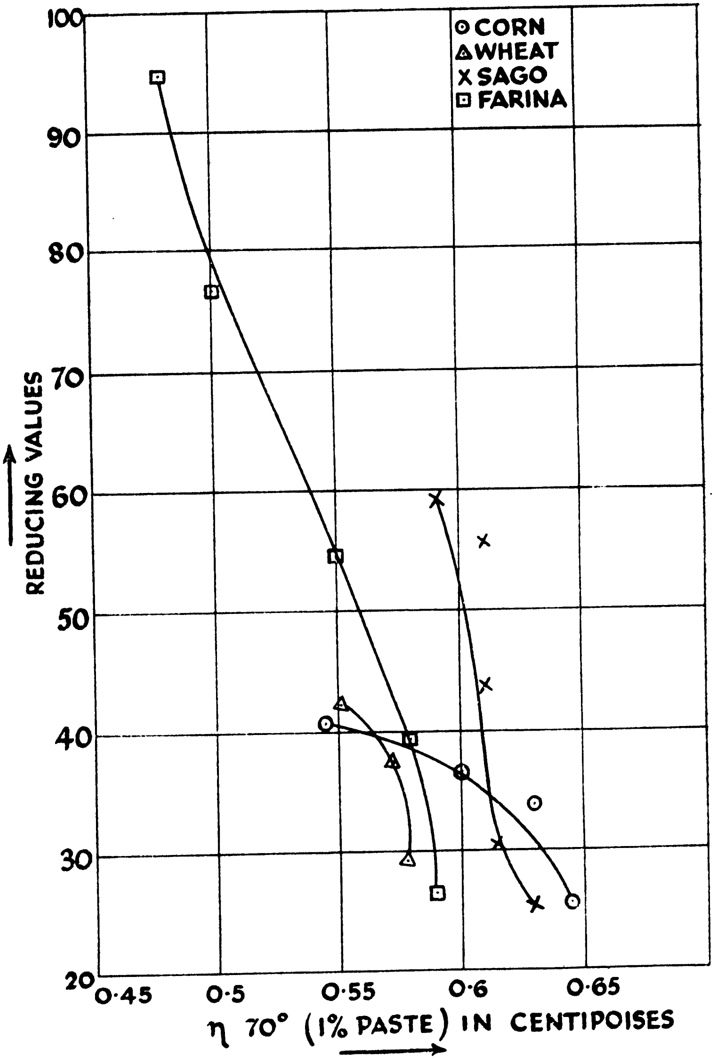


Fig. 7.

As already pointed out in Parts I and II, considering all properties, farina starch is affected the most, followed by sago, wheat and corn in the decreasing order of degradation ; in other words root starch like farina is more prone to attack by acids and oxidising agents. It should be added that the commercial products, that were examined for their physical and chemical properties, show but little sign of degradation.

The inherent tendency of raw starches to thin down on continuous boiling and stirring, is eliminated on modification. The modified products once brought to the boiling temperature in their aqueous solutions, do not tend to lose in their consistency by subsequent prolonged heating and they give smooth homogeneous pastes in a much shorter cooking period.

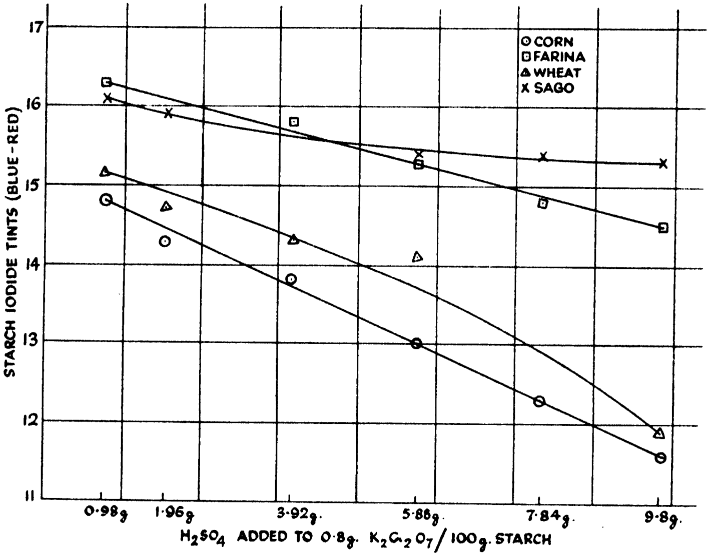


Fig. 8.

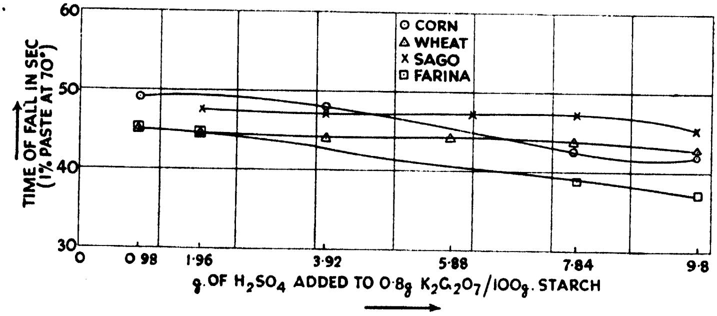


Fig. 9.

Finally, the present modified products compared very favourably with raw and commercial products with regard to their textile qualities such as (i) penetration, (ii) increase in weight, (iii) tensile strength, (iv) feel (softer) and (v) binding values. Briefly the degraded products are more adaptable to textile operations than the raw varieties.

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2—REGAIN OF TEXTILES AND HUMID ATMOSPHERE CHANGES

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Introductory

The equilibrium regain of textiles in atmospheres of constant temperature and water vapour content has been extensively studied, but only isolated and incompleted attempts have been made to determine the effect of a change in atmospheric conditions on the rate of change of regain and temperature of the textile.

The effect of changed atmospheric conditions on regain is of much importance to the textile industry, for on it depends all calculations on drying and conditioning of cloth, yarns, etc. It is of even greater importance for the hygiene of clothing (cf. Cassie, Atkins and King, *Nature*, 1939, **143,** 163), and as will be seen from later discussion, it explains why only *hygroscopic* textiles have been accepted for clothing purposes.

Extensive theoretical and experimental work has recently been carried out at Torridon. The basis for most drying, and conditioning problems has been established, and the same considerations will serve to discuss the physical factors which control the hygienic characteristics of clothing. The academic and mathematical work and its experimental verification have been reported elsewhere The present paper gives a more physical basis for the calculations, and discusses the significance of the results for textile and clothing problems. The formulae developed in the present discussion are all approximate, but they have the merit of reasonable simplicity, and the approximations are close enough for use in practical problems.

Rate of Absorption of Water Vapour by Textile Fibres

Many have long supposed that the slow rate of drying and conditioning of textiles, particularly of wool, was in part due to slow sorption* of water vapour by the fibres. Calculations on rate of change of regain could only be made when the effects of the resistance offered by the fibre itself on the velocity of absorption could be estimated. Our first experiments were therefore designed to determine this factor. They have shown conclusively that the effect on the velocity is negligible compared with that due to diffusion of water vapour through even the smallest layers of air and to the difficulty of the fibres in losing or gaining heat generated or absorbed when the regain increases or decreases.

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* "Sorption" will be used to cover the processes of absorption and desorption.

This valuable property of textile fibres is due to their small diameter. The resulting very large surface-volume ratio means that even though diffusion determines the rate of transport of water vapour from the surface to the interior of the fibres, the time required for a fibre to come to within 80% of its final water content when a change in water vapour concentration occurs at its surface is less than 1/10 sec.; this is, of course, neglecting complications due to heat of sorption.

Regain Properties of Textiles in Relation to the Humid Atmosphere

The two factors of a humid atmosphere which are of importance for control of the regain of textile fibres are temperature and water vapour content, or water vapour pressure. Regain may be changed either by a change in temperature or by a change in water vapour content of the atmosphere, and the two factors are best considered separately. Textile practice usually considers regain to be dependent only on relative humidity. This is in fact nearly true ; if regain is plotted against relative humidity, one finds the curve little changed by a change in temperature. Relative humidity is itself dependent on the temperature and water vapour content of the atmosphere, and if these two variables are changed in such a way as to leave relative humidity unchanged, then regain is also left almost unchanged ; it is this fortunate circumstance that makes relative humidity so useful as a reference standard for regain ; it enables the two variables, temperature and water vapour content, to be replaced by one, relative humidity. The present discussion will use relative humidity as much as possible, but as change in the two variables, temperature and water vapour content, must be discussed separately, they must at times replace the more practical single variable.

Before considering in detail the effects of change in either temperature or water vapour content of the atmosphere, it is useful to review in a general way the regain properties of textiles in relation to these two factors. One property has already been noted : the fibres may be considered as at all times in equilibrium with the temperature and water vapour content of the atmosphere in their immediate neighbourhood. A second important property is that within the range of regains of practical interest, the water content in any given volume of textile fibres is very large compared with the water content in the same volume of air. Thus, in 1 litre of textile fibres and air of overall density 0·2 gm./c.c., the textile, if wool, will contain roughly 20 gm. of water at 20° C. and 45% R.H., whilst the air contains rather less than 0·01 gm. This means that if textiles are brought to equilibrium with one set of atmospheric conditions (i.e. temperature and water vapour pressure) and the conditions are suddenly changed, a large volume of air will have to pass over the textile before appreciable change of regain can occur. Hence, during any small time interval, at any time after the change in the atmosphere, the textile may be regarded as having a constant regain, even when in this time interval it picks up what is to the air a considerable mass of water vapour.

A third important property is the large heat of sorption associated with any change of regain. The value of the heat of sorption depends on the regain of the fibres and varies from fibre to fibre, but it is never less than the latent heat of evaporation of water ; a fair average value for wool fibres is 650 cals. for every gm. of water absorbed or liberated. Take again the example of wool at a density of 0·2 gm. per cc. If the regain changes from 10% to 11%, 1 litre of the mixture will absorb 2 gm. of water, and the heat of absorption which must be liberated is 1300 cals. The heat capacity of the wool is 60 cal./°C., so that there is sufficient heat produced to raise the temperature of the wool by 22°C.

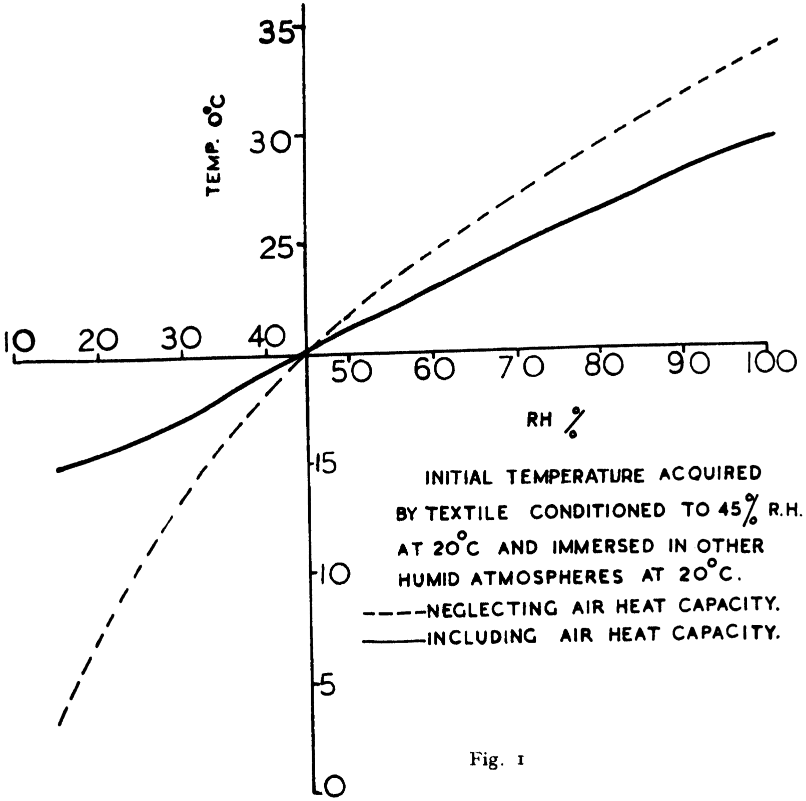

Fig. 1

Consider now the combined effect of the two properties just discussed when a change occurs in the water vapour pressure of the atmosphere. Suppose the wool is conditioned to 45% R.H. at 20°C., so that its regain is 10%, and that it is put into air at 65% R.H. and 20°C. Equilibrium between the wool and the new atmosphere can be attained in two ways.

(i) The regain of the wool can increase until it is in equilibrium with 65% R.H. when the regain is 14%, or (ii) the temperature of the wool and the air immediately in contact with it can increase until the new water vapour pressure represents 45% R.H., the regain of the wool remaining unchanged. The water vapour pressure at 65% R.H. and 20°C. is 11·4 mm., and if this pressure is to give 45% R.H., the saturation pressure must be 11·4/0·45, or 25·2 mm.; tables give the corresponding temperature as 26°C.

The problem is to choose between the two possible equilibria with the new atmosphere conditions. The first can only be attained when a very large volume of air has passed over the wool, whereas the second can easily be attained because of the very large heat of absorption of water vapour ; the second can, in fact, be rapidly attained and will be the first form of equilibrium set up between the wool and new atmosphere. Hence, to find the conditions applicable to the textile and the atmosphere immediately surrounding it when a change in atmosphere conditions occurs, one uses the hypothesis that the regain of the textile is unchanged.

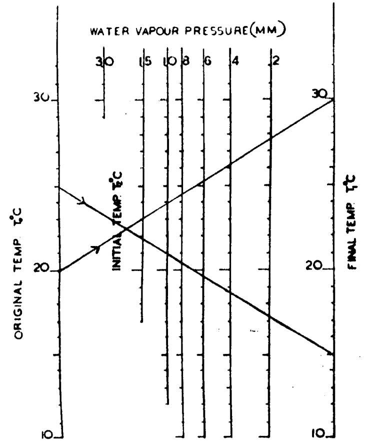

Fig. 2

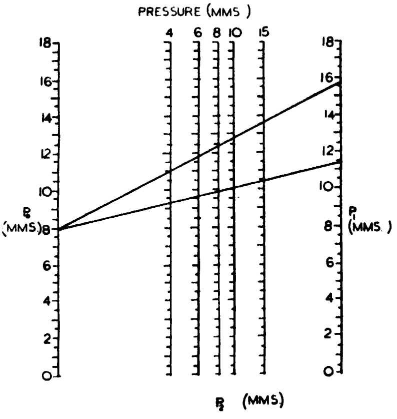

Fig. 3

The broken line graph of Fig. 1 shows temperatures calculated in this way for textiles conditioned in an atmosphere of 20°C. and 45% R.H., and subsequently immersed in atmospheres of 20°C. and R.H.'s between 15% and 100%.

The temperatures shown on the graph are not applicable for wool only, but hold for all textiles which have been conditioned to 45% R.H. at 20°C. The regains of the textiles will be different, but as regain is assumed constant in the calculation, it has no bearing on the results.

A change in temperature of the atmosphere, with constant water vapour pressure, can be similarly discussed. Since the regain remains constant, the R.H. of the air at the textile must remain unchanged ; if the water vapour pressure of the air is also unchanged, this means that the temperature of the textile must remain unchanged. Thus, under the condition of constant water vapour content, the textile offers great resistance to temperature change.

The Heat Capacity of the Atmosphere and Textile Changes

The calculations just given on the rise in temperature of a textile with increase in water content of the atmosphere, have neglected cooling effects due to the heat capacity of the air. The amount of air that must pass through the textile to give it, say ½ gm. of water, is at least 200 litres, and this amount of air can take 70 cals. of heat from the textile for each degree centigrade that the textile temperature is above 20°C. Assuming an average textile temperature of 23°C., the air can remove rather more than 200 cals. This is a very large proportion of the heat, 360 cals., which the textile can obtain by absorbing water vapour from 200 litres of the humid air.

A balance has to be struck between the heat gained by the textile from absorption of water vapour, and that lost by the cooling capacity of the air. This can be done mathematically by using the hypothesis that the textile regain is unchanged whilst the new conditions are being established.

The mathematical discussion is much simplified by introduction of a terminology which will now be given. There are in every case of change of atmospheric conditions three temperatures and water vapour contents of special significance. There are the original temperature and water vapour content to which the textile has been conditioned before any change occurs ; they will be referred to as the *original* conditions, and they will be designated by (T_0, C_0). Secondly there is the atmosphere incident on the textile when the change occurs, and to which the textile ultimately becomes conditioned ; the temperature and water vapour content of this atmosphere will be called the *incident* (or *final*) conditions, and they will be designated by (T_1, C_1). Thirdly there are the conditions which hold at the textile immediately the change in atmosphere occurs ; these will be called the *initial* conditions, and will be designated by (T_2, C_2). The initial conditions are deduced from the original and final conditions on the assumption that the regain is unchanged from its original value. An example of an initial temperature calculation has been given in the previous section: this determination neglected the heat capacity of the atmosphere, and the purpose of the present section is to determine initial temperatures and water vapour contents taking into account this heat capacity.

An increase in temperature with a constant water vapour content happens to be the simplest case. If the specific heat of the textile is taken as zero, it can neither gain nor lose heat to the air. 1 c.c. of air in traversing the textile under these circumstances, must satisfy the heat balance equation:

$$\rho_a \, c_a \, (T_1 - T_2) = q(C_2 - C_0) \qquad \text{......................... (1)}$$

where ρ_a is the density of the air,

c_a is the specific heat of the air,

and q is the heat evolved when 1 gm. of water vapour is absorbed by the textile.

Since the regain of the textile is assumed constant in determining T_2 and C_2, the quantities (T_2, C_2) and (T_0, C_0) must satisfy Kirchoff's relation.* The integrated form of this equation gives approximately:—

$$(C_2 - C_0) = \frac{Q}{RT_a^2} \quad C_0(T_2 - T_0) \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

where Q is the heat of sorption of 1 mol. of water vapour,
R is the gas constant per mol.,
and T_a is the absolute temperature (T_0°C. + 273)
Substitution in equation (1) gives :—

$$\rho_a\, c_a\, (T_1 - T_2) = \frac{qQ}{RT_a^2}\; C_0(T_2 - T_0) \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

Equation (3) determines T_2 in terms of T_1, T_0 and C_0, all of which are given.

Take as an example the case where the temperature of the air is increased from 20° C. to 30° C., the water vapour concentration remaining at 7.8×10^{-6} gm./c.c., corresponding to 45% R.H. at 20° C. If q is taken as 650 cal./gm., equation (3) becomes:—

$$(T_1 - T_2) = 1{\cdot}2\ (T_2 - T_0)$$

$$\text{or} \qquad \underline{T_2 = 24{\cdot}5^\circ \text{ C.}}$$

The simple form of equation (3) makes it possible to give the results comprehensively as a nomogram. If

$$F = \frac{qQ}{R\, T_a^2\, \rho_a\, c_a} \quad C_0,$$

equation (3) becomes :—

$$(1 + F)\, T_2 = T_1 + F\, T_0 \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (4)$$

The nomogram of Fig 2 gives the results of this equation for various values of F, or of the water vapour content of the atmosphere. The lines are numbered in the diagram according to water vapour pressure, as this is more useful than water vapour content. The temperature scale is the same for all the vertical lines. The nomogram is used by joining the points T_0 and T_1 by a straight line: this line intersects the vertical water vapour pressure line at a point corresponding to the initial temperature. In the example just worked out, the water vapour pressure was 8 mm., and T_0 and T_1 were 20° and 30° C. The line joining these points intersects the 8 mm. line at 24·5° C. Had the water vapour pressure been 15 mm., the initial temperature would have been 23° C., and if 2 mm. it would have been 27·7° C.

The 30, 15 and 10 mm. lines are terminated at the temperatures where saturation occurs ; the formula does not apply to saturation or higher water vapour pressures. One should also remember that formula (3) is approximate, and should not be used for too large temperature changes ; fair accuracy will be obtained for changes up to 15° C.

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* Shorter (*J. Text. Inst.* 1924, 15, T328).
Hedges (*Trans. Farad. Soc.*, 1926, 22, 178).

Change in water vapour concentration can be similarly treated. The heat balance equation is in this case:—

$$\rho_a c_a (T_2 - T_0) = q (C_1 - C_2) \quad \dots\dots\dots\dots\dots\dots\dots (5)$$

Here C_1 and C_0 are given, and C_2 or T_2 is required.

Substituting for $(T_2 - T_0)$ from equation (2) gives :—

$$\rho_a c_a (C_2 - C_0) = q \frac{Q}{RT_a^2} C_0 (C_1 - C_2) \quad \dots\dots\dots\dots\dots\dots\dots (6)$$

Inserting numerical values, (6) can be written :—

$$(p_2 - p_0) = \frac{1{\cdot}4 \times 10^4}{T_a^2} p_0 (p_1 - p_2) \quad \dots\dots\dots\dots\dots\dots (7)$$

where p_0, etc., are the water vapour pressures in mm. corresponding with C_0, etc.

Equation (7) determines p_2 in terms of the known quantities, p_0 and p_1. The temperature of the textile and the issuing air is also often required. It can be obtained by substituting for C_2 in equation (5) from equation (2). The result is:—

$$(\rho_a c_a + \frac{Qq}{RT_a^2} C_0) (T_2 - T_0) = q (C_1 - C_0) \quad \dots\dots\dots\dots\dots\dots (8)$$

Take as an example the case previously discussed, where T_0 is 20° C., and the water vapour content was increased from 45% to 65% R.H., or from $8{\cdot}35$ to $12{\cdot}0 \times 10^{-6}$ gm./c.c.

Inserting these values in (6) gives:—

$$\underline{C_2 = 10{\cdot}4 \times 10^{-6} \text{ gm./cc.}}$$

and (8) gives

$$\underline{T_2 = 23{\cdot}7° \text{ C.}}$$

If pressures are used, p_0 is 7·9 mm. and p_1 is 11·4 mm.

Equation (7) gives

$$p_2 = 9{\cdot}8 \text{ mm.}$$

In practice, equation (7) is the most useful, and nomograms can be constructed for it just as they were for the temperature change equation. Figs. 3 and 4 are nomograms of this equation for T_0 equal to 20° C., and 50° C. The nomograms are used in the same way as for temperature changes. The vertical scales are again identical. One point of difference is that the vertical line corresponding to p_0 is taken in reading off the initial water vapour pressure. The example just given is shown by the transverse line in Fig. 3. The original water vapour pressure was 7·9 mm. and the final was 11·4 mm. The line joining these points cuts the 7·9 mm. line—roughly the 8 mm. line—at 9·8 mm.

An important point regarding the initial temperature and water vapour pressure is that they are largely determined by limitations of the atmosphere, and have little bearing on the textile fibre under consideration. They have been deduced from the hypothesis that the regain of the textile remains unchanged when a sudden change in atmospheric conditions occurs ; the textile, in fact, maintains a constant relative humidity in the atmosphere when changes occur. The position of the vertical lines in the nomograms is therefore determined by the ratio of the heat required to raise any given volume of the atmosphere through 1° C. to the heat required to evaporate enough water into this volume to maintain the original R.H. of the atmosphere when increased in temperature by 1° C. Heat of desorption of water from the textile actually replaces heat of evaporation from liquid water. These two are nearly equal for all textiles in normal atmospheres, and whenever this is true, the nomograms can be used.

Application to Drying and Conditioning Calculations

The theory of the wet bulb hygrometer has long been in use for calculation of surface temperatures of drying materials when the surface is saturated with water. Suppose, for example, that cloth is being dried from a high regain, say 50%, in air of 80% R.H. and 54° C. The temperature of the cloth will be that of a wet bulb under these conditions ; its temperature is 50° C. The rate of drying is proportional to the difference of the water vapour pressure in the air, in this case 90 mm., and the saturation water vapour pressure of the cloth, which at 50° C. is 92·5 mm. These calculations are fundamental to any investigation of drying efficiency. When, however, free water is no longer present on the fibres, the wet bulb theory fails to give the temperature or the water vapour pressure in equilibrium with the cloth, and rate of drying calculations cannot be made. Conditioning is concerned only with the region where no free water is present on the fibres, and conditioning calculations cannot be made at all through use of the wet bulb theory. The theory just given covers the region where no free water is present, or the region of low regains. It makes possible extension of drying calculations to low regains, and also makes possible conditioning calculations. Some examples of its use in conditioning calculations are given below.

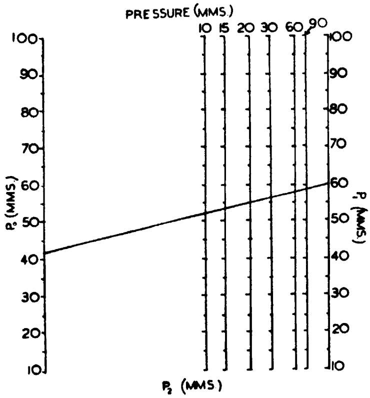

Fig. 4

Rate of conditioning in textiles must in all cases be proportional to the difference between the water vapour pressure of the humid atmosphere and that at the surface of the material being conditioned. It will in addition be proportional to rate of flow of the humid air over the material, but at present this and other factors will be omitted.

Suppose a mass of wool fibres at 10% regain is to be conditioned to 13% in a chamber with air at 20° C. and 65% R.H. The water vapour pressure of the incident air will be 11·4 mm. That of air in equilibrium with the cloth can be found from the nomogram of Fig. 3. The fibres are at 10% regain, or are conditioned to 45% R.H., or to 7·9 mm. water vapour pressure at 20° C. This is the example already given on use of the nomogram, and the water vapour pressure in equilibrium with the wool is 9·8 mm. The initial rate of conditioning is proportional to the difference between the water vapour pressures 11·4 mm. and 9·8 mm. or to 1·6 mm.

Consider now the rate of conditioning when 13% regain is approached. The R.H. giving this regain for wool is 60% ; or fibres conditioned to 10·5 mm. water vapour pressure at 20° C., have air of 11·4 mm. and 20° C. incident on them ; i.e. p_0 is now 10·5 mm. and p_1 is 11·4 mm. The nomogram gives p_2 as 11·0 mm. The rate of conditioning is therefore proportional to 0·4 mm. The rate of conditioning at 13% is thus only one quarter that when the fibres were at 10% regain.

An important question for conditioning which can be investigated by means of equation (7) or appropriate nomograms, is the effect of the temperature of a conditioning chamber on rate of conditioning. Take again the case of cloth at 10% regain being conditioned in an atmosphere of 65% R.H. If this atmosphere is at 5° C., the excess of the water vapour pressure in the chamber over that in equilibrium with the cloth is, from equation (7) 0·9 mm. If it is at 20° C., the difference between these water vapour pressures is 1·6 mm. At 50° C., the water vapour pressure in the chamber is 60 mm., and the cloth is conditioned to 41·5 mm. at 50° C. The nomogram of Fig. 4 is for 50° C., and the line joining the 41·5 and 60 mm. points on the p_0 and p_1 axes would cut the vertical 40 mm. line at approximately 56·5 mm. The water vapour pressure difference is therefore 3·5 mm. Hence the rates of conditioning of wool at 10% regain in an atmosphere of 65% R.H. are in the ratio of 0·9:1·6:3·5 for conditioning chamber temperatures of 5°, 20° and 50° C. It is worth noting that the water vapour pressures in the chamber at these temperatures are in the ratios of 1 to 2·7 to 21 ; the increase in rate of conditioning with increase in temperature is thus very poor compared with the large increase in water vapour content required at the higher temperatures. If 90% R.H. or 15·8 mm. pressure, was used at 20° C., the water vapour pressure in equilibrium with the cloth at 10% regain would be from Fig. 3, 12·4 mm., and the water vapour pressure difference is 3·4 mm. ; this is almost the value obtained at 50° C. with 65% R.H. Moreover, the water vapour pressure required in the chamber at 20° C. and 90% R.H. is only 15·8 mm. as compared with 60 mm. required at 60° C.

These figures indicate that conditioning machines could be most efficiently operated at 20° C. or lower temperatures with adequate air circulation to maintain a high R.H. throughout the machine. Drying machine efficiency can be increased by an increase in temperature, but no corresponding gain can be obtained for conditioning. Hence attention to air circulation to maintain a high R.H. throughout the chamber is even more important for conditioning than for drying machines.

Estimation of the Time Required for Conditioning

Calculations so far made have determined the initial temperature and water vapour concentration in equilibrium with textiles at the moment a change in atmospheric conditions occurs: they have been based on the assumption that the regain of the fibres can be taken as unchanged when the atmospheric conditions change. This assumption is fully justified for calculation of initial temperatures, and it can be used to give some idea of the time required for conditioning to take place. Suppose humid air (T_o, C_o) flows through a mass, m, of textile fibres until these are fully conditioned, and is then changed to air (T_o, C_1) where C_1 is greater than C_o. The exit air immediately acquires conditions (T_2, C_2) given by equations (6) and (8): the exit air has a lower water vapour concentration than the incident air, and a gradual increase in regain occurs. As the regain changes, the concentration-temperature relation (2) changes so that C_2 approaches C_1, and T_2 approaches T_o ; ultimately the regain of the fibres acquires the value which is in equilibrium with the conditions (T_o, C_1), and the change is complete.

If N be the number of c.c.'s of humid air passing through the fibres per second, the rate of change of regain is given by:

$$m \frac{dM}{dt} = N (C_1 - C_2{}^1) \qquad \text{(8a)}$$

where $C_2{}^1$ is the water vapour concentration in equilibrium with the textile at any time, t, when the air (T_o, C_1) is incident on the textile, M is the regain expressed as a fraction. The ordinary relation of M to T and C for static atmospheric conditions will be taken as (cf. Henry, *Proc. Roy. Soc.*, 1939, (4), **171**, 215-241):

$$M = A + \sigma C - \omega T \qquad \text{(9)}$$

where A, σ and ω are constants.

At the time, t, the fibres are conditioned to give exit air ($T_2{}^1$, $C_2{}^1$) with incident air (T_o, C_1) ; the condition of the fibres is thus the same as though they had come to equilibrium with an atmosphere (T_o, C_D), where, from equation (6), C_D is given by approximately:—

$$\rho_a c_a (C_2{}^1 - C_D) = q \frac{Q}{RT_a{}^2} C_o (C_1 - C_2{}^1)$$

$$\text{or} \quad (C_2{}^1 - C_D) = \alpha (C_1 - C_2{}^1) \qquad \text{(10)}$$

$$\text{and} \quad \alpha = \frac{qQ C_o}{\rho_a \, c_a \, RT_a{}^2}$$

α will be taken as constant.

Equation (9) becomes for the present case

$$M = A + \sigma C_D - \omega T_o \qquad \text{(11)}$$

$C_2{}^1$ can be determined in terms of the given quantities, T_o, C_o and C_1, from equations (10) and (11). Substitution in (8a) gives:

$$\frac{\sigma(1 + \alpha)\, dM}{A + \sigma C_1 - \omega T_o - M} = \frac{N}{m} dt$$

or

$$\Delta M = \Delta_o M \left(1 - e^{-\frac{N}{m} \frac{t}{\sigma(1+\alpha)}}\right) \qquad \text{(12)}$$

where $\Delta_o M$ is the total change in regain and ΔM is the change that has occurred at any time, t. The variation of $C_2{}^1$ with t will clearly follow the same law.

In equation (12), a is of the order of 1 for ordinary humid atmospheres. The factor, σ is, however, very large ; it is normally of the order of 10^4 c.c./gm. This means that the time required for appreciable change of regain, or $C_2{}^1$ to occur is very large. Hence the difficulty of drying or conditioning textile fibres.

Application To Hygiene of Clothing

The slow rate at which the water content of a textile can be changed by a change in atmospheric temperature or water vapour content is a great source of trouble to the textile manufacturer, but it makes hygroscopic textiles attractive for clothing purposes (cf. Cassie, Atkins and King, *Nature*, 1939, **143**, 163). Clothing is normally worn to decrease heat loss from the body. This is the primary function of clothing, but it is well known that the body can in the course of time adapt its thermal conductivity to give the desired heat loss under quite varied temperature conditions. The body requires time to adjust its thermal conductivity after a temperature change occurs, and if the surrounding temperature be suddenly decreased, the thermal adjustment of conductivity will be temporarily too small, and the body heat loss unduly large. Clothing will help greatly in avoiding such effects if it mitigates and delays the change of temperature at the skin.

The condition in a normal humid atmosphere is that water vapour content is roughly constant. Thus, the water vapour content is roughly the same in a well ventilated room as out of doors, though the temperature out of doors is lower. Changes in a normal atmosphere therefore consist largely of the type (T_0, C_0) to (T_1, C_0). This change passes through textiles first as an initial temperature change, followed by a much slower change which ultimately gives the temperature T_1. The initial temperature change can be obtained from the nomogram of Fig. 2.

Take the example of T_0 equal to 25° C. and T_1 equal to 15° C. At 15 mm. water vapour pressure the initial temperature is 22° C. and this initial temperature can be as low as 17·3° C. when the water vapour pressure is 2 mm. The rapid change as the initial temperature is established is thus much smaller at high water vapour pressures than at low. Hygroscopic textiles will therefore give greater protection against sudden temperature changes in humid tropical climates than in dry low temperature atmospheres. In Britain the average water vapour pressure is approximately 10 mm. (cf. Averages of Humidity for the British Isles, H.M. Stationery Office, M.O.421, p. 26), and the initial temperature change will usually be less than one half the total temperature change.

The initial temperature will not be established throughout the textile immediately the temperature change occurs. It will be set up as though the textile had no hygroscopic properties, and the temperature had been changed from T_0 to T_2 instead of from T_0 to T_1. Take as an example the case where air is blown through a mass of textile as discussed in the preceding section. The equation for rate of temperature change is determined solely by the specific heat of the textile, and is:—

$$S\,m\frac{dT_i}{dt} = N \quad \rho_a\, c_a\, (T_2 - T_i)$$

where S is the specific heat of the textile and T_i is the initial temperature. It is assumed that the rate of heating is proportional to the temperature difference between the air and the textile. Integration of this equation gives:—

$$(T_2 - T_i) = (T_2 - T_o)e^{-\frac{N}{m}\frac{\rho_a c_a}{S}t} \quad \text{.................} (13)$$

The time required for the change from T_i to T_2 can be determined from equation (12). If $\Delta_o M$ is the total change of regain involved in the change (T_o, C_o) to (T_1, C_o), equation (12) is just repeated. The temperature change proceeding simultaneously with the change of regain is that from T_o to T_1, and this change in temperature follows the same function as the regain, i.e.

$$(T_1 - T_f) = (T_1 - T_i)\, e^{-\frac{N}{m}\frac{t}{\sigma(1+\alpha)}} \quad \text{..............} (14)$$

where T_f is the temperature of the textile when both the initial temperature change and the slow temperature change associated with change of regain are included. Substituting T_i from (13) gives:

$$(T_1 - T_f) = (T_2 - T_o)e^{-\frac{N}{m}\left\{\frac{\rho_a c_a}{S} + \frac{1}{\sigma(1+\alpha)}\right\}t} + (T_1 - T_2)e^{-\frac{N}{m}\frac{t}{\sigma(1+\alpha)}}$$

Since $\frac{\rho_a c_a}{S} \gg \frac{1}{\sigma(1+\alpha)}$, this equation may be taken as:

$$(T_1 - T_f) = (T_2 - T_o)e^{-\frac{N}{m}\frac{\rho_a c_a}{S}t} + (T_1 - T_2)e^{-\frac{N}{m}\frac{1}{\sigma(1+\alpha)}t} \quad \text{.........} (15)$$

The first term is clearly that contributed by the initial temperature and the second is that contributed by the temperature change associated with regain change. If the fibres had no hygroscopic properties, the total temperature change would occur as the first term in equation (15): i.e.

$$(T_1 - T) = (T_1 - T_o)e^{-\frac{N}{m}\frac{\rho_a c_a}{S}t} \quad \text{.............................} (16)$$

Consider now the rate at which the exponential terms decrease in the two cases. If t_H be the time required for the hygroscopic term to reach a given value, and t_s be the time required for the specific heat term to attain the same value:—

$$t_H : t_S = 2\sigma : \frac{S}{\rho_a c_a}$$

since α is usually around unity for normal atmospheres. Insertion of numerical values for wool gives the ratio of these two times as 20:1. Hence the time required to establish a temperature change in wool is roughly twenty times the time that would be required were the fibres non-hygroscopic; the more accurate mathematical work published elsewhere shows the ratio of the two to be even larger because of interaction of the specific heat and heat of sorption factors. One notes that the ratio of the two times increases as σ increases. σ is proportional to the rate of increase of regain with relative humidity, so that the steeper the regain curve, the more difficult it is to change the temperature of the textile.

The discussion just outlined shows that hygroscopic textiles can give a large measure of protection against sudden temperature changes at the skin. A temperature change in the surrounding atmosphere begins to be propagated through textiles as if they had no hygroscopic property; but once the initial temperature is attained, the rate of change of textile temperature becomes very slow. Fig. 5 shows a curve obtained experimentally for wool: air with a constant water vapour pressure and at 15° C. was blown through a cylinder of wool until this was fully conditioned; the temperature of the air entering the wool was then raised to 31° C., and curve B shows the rise in temperature with time at the centre of the cylinder. Rapid establishment of an initial temperature of 22·5° C. is clearly shown, and, this is followed by the slow change to 31° C. If the wool was non-hygroscopic, its temperature would have increased according to curve C. The ratio of the times required to reach say 27° C., by following curves B and C is roughly 20:1. Theory and experiment thus both agree that hygroscopic textiles prevent sudden atmospheric temperature changes from reaching the skin suddenly. The degree of protection increases as σ increases, and this factor is proportional to the rate of increase of regain with relative humidity; or very roughly, the greater the regain of a textile, the greater is its protective power; provided, of course, the absorbed water does not give surface wetting of the fibres. Animal fibres are superior to all others in these respects: they absorb more water than other textiles without losing their physical properties; in particular they show no surface wetting. They have long been recognised as supreme in avoiding sudden temperature changes at the skin, and there can be little doubt from the preceding discussion that this is due in a large measure to their high regains.

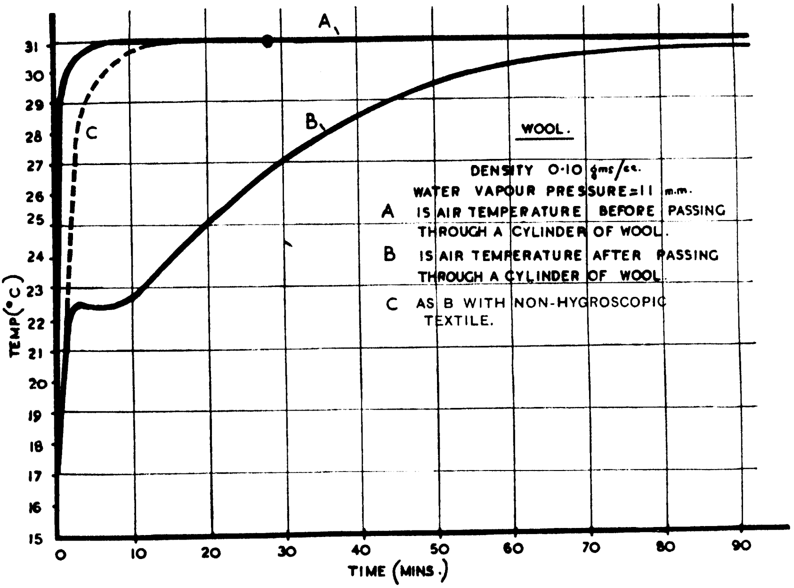

Fig. 5

SUMMARY

The observation that textile fibres pick up and lose water vapour very rapidly is used to discuss water vapour and heat exchange between a humid atmosphere and the fibres.

The results are fundamental for calculations on textile drying and conditioning processes, and examples of their application are given.

The theory is also applied to physical problems of hygiene of clothing. It is shown that hygroscopic fibres can give protection against sudden temperature changes in normal humid atmospheres, and the protection increases with the slope of the regain—R.H. curve for the fibres.

ACKNOWLEDGMENTS

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Wool Industries Research Association,
Torridon,
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TRANSACTIONS

3—EMULSION OILING OF MERINO WOOL

By P. P. Townend

The purpose of the experiment was to determine the critical amount of lubricant which might be added to fine woollen blends in order to obtain maximum yarn strength. It has been shown that the strength of a worsted roving first increased and then decreased with continued additions of oleine,[1] and in the case of a woollen yarn oiled with varying amounts of olive cream, the breaking strength increased as the percentage of lubricant decreased from 30 per cent. to 22 per cent. on the weight of the wool.[2] Since it is generally agreed in the fine woollen trade that emulsion oiling is superior to that with oleine alone, the experiment was confined to the former method.

Experimental.

Six 13 lb. lots of 64's scoured Queensland wool were oiled with different amounts of emulsion, carded, spun and tested for breaking load, extension at break, count and twist. The emulsion used consisted of 50 per cent. emulsifiable oleine (Price's Brown Cloth Oil) and 50 per cent. water. The amount of lubricant used for each lot is given in Table I. In each case it was applied by hand, using a bottle with a finely perforated cork. Immediately after oiling the wool was given a thorough mixing. It was then directly carded and spun. This procedure was carried out in each case so that the treatment of every lot was the same. The carding engine used was a typical West of England three part set. The machine was fettled and set previous to the experiment. No alterations of the setting were made during the passage of the various lots through the machine, but it was found necessary to alter the speed of the carder feed sheet as the higher amounts of lubricant were added, owing to the failure of the slivers to touch each other on the feed lattice. The various lots were processed in the order of ascending amounts of lubricant. The slubbing was condensed at 8·5's, and spun on a Platt's mule to 12's W. of E. with 8 turns per inch. The card was fettled after the passage of each lot to reduce the possibility of any fibres from one lot finding their way into a succeeding lot.

Testing.

Previous to the experiment, 10 spindles on the mule were marked, and the bobbins from these spindles for each lot of yarn were marked and stored immediately after spinning in a wire cage which stood over a saturated solution of ammonium sulphate in a closed metal box, since no constant humidity room was available. In order that any variations due to differences in temperature and humidity during testing might be equally spread over the six lots processed the following method was adopted. One bobbin from each lot and from the same marked spindle was taken, making six bobbins in all, and these were tested for breaking load, extension, count and twist at the same time. This same routine was adopted with the bobbins obtained from the six lots spun on spindle No. 2, etc. In order to test over the whole amount of wool processed, one third of the tests was made on the outer yarn of the bobbins, one third from the centre of the bobbins, and the remainder from the inside yarn.

The breaking load and extension of the greasy yarn were determined on a Goodbrand single thread tester which registered both at the same time. 20 observations were made for each bobbin, using 18 inch lengths of yarn, so that 200 observations were obtained for each lot processed. The amount of twist in the yarns was determined on 10 inch lengths using the Barker's Twist Testing Machine. In each case 10 tests were made per bobbin giving 100 tests from each lot.

The method adopted for count determination was to take three consecutive 30 yard hanks from each bobbin and weigh on an ordinary balance. From these weighings, the count was obtained as an average of 30 determinations.

The results of the above tests are set out in Table I.

Table I.

% Emulsion on Weight of Wool	Average Count W. of E.	% Average Variation in Count	Mean Turns per 1″	% Deviation from mean per Turns 1″	Mean Breaking Load (oz.)	% Deviation from Mean Breaking Load	% Mean Extension at Break on 18″ length	% Deviation from Mean Extension
0	11·7	3·4	7·9	10·1	18·2	7·4	19·8	15·7
5	11·9	1·7	7·5	9·6	17·0	10·4	19·4	16·7
10	12·0	2·2	7·7	8·9	17·1	7·1	19·6	14·6
15	12·4	1·6	7·8	10·1	17·1	8·5	19·3	16·4
20	12·9	1·7	7·9	12·1	17·3	10·3	18·7	18·8
30	13·1	3·1	7·6	10·7	16·3	9·4	18·2	17·0

In order to compare the breaking loads of the yarns spun with the different amounts of lubricant, these have been reduced to a standard count of 12's W. of E. on the assumption that the strength in each case is inversely proportional to the observed count. These values are given in Column 3 Table II, whilst Fig. 1 shows them plotted against the amount of lubricant added to each lot.

In order to act as a check on the oiling, the yarn from the odd marked spindles which had been used for strength determination was extracted and dried in an air oven at 105° C. for two hours, then weighed, the loss in weight giving the combined oil and moisture present in the yarn tested. The same procedure was carried out on one 30 yard hank, again from the odd marked spindles. In this way the figures given in Column 2 Table II were obtained, each being the average of ten tests. Since in drying wool in an air oven there is always 0·5 per cent. of moisture left in the wool, this correction has been made in each case. The figures given are in the same order as the amounts of lubricant, but they do show that in every case quite a proportion of it was lost during carding. This is attributed to the operation of cleaning the card after the passage of each lot and to the small lots of wool processed, both of which were unavoidable.

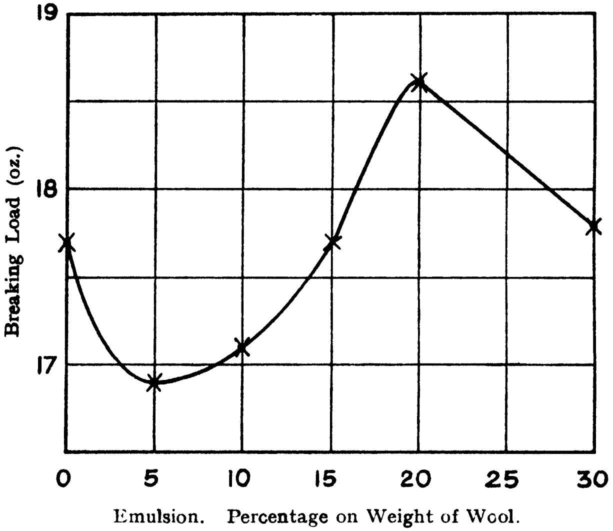

Fig. 1

Discussion of Results.

It will be seen that the yarn count increased with the increase in the amount of lubricant. The variations in count are put down to the large difference in the amounts of lubricant, especially in view of the fact that half in each case was water. The variation might have been partially overcome by altering the weigh box on the hopper so that the same amount of wool fibre was present in every weigh regardless of lubricant, but this would have meant either speeding up the machine in order to condense each lot to the same count, or scouring the yarn previous to testing in order to arrive at a uniform count. The first method would have raised the question as to whether fibre breakage was appreciably altered by an increase in the speed of the doffers and workers. In actual practice yarns are tested and woven in the grease and it was this consideration which prompted the present method.

The twist was fairly regular. The low number of turns per inch was chosen in order to emphasise the fibre breakage in carding and lessen the masking effect of twist in the subsequent strength testing.

Table II.

% Emulsion on Weight of Wool.	% Combined Oil and Moisture found in Yarn	Breaking Load of Yarn Corrected for Count (oz.)
0	17·14	17·7
5	19·08	16·9
10	19·77	17·1
15	20·79	17·7
20	22·39	18·6
30	24·94	17·8

The extension of the yarns at break shows that they were all greatly in excess of that needed in weaving. It is doubtful if mere measurement of extension at break is of any real value from a weaving utility point of view, since weaving involves rather continuous small extensions and contractions along the length of the yarn as it passes forward to form the cloth. Some form of elasticity test would be more likely to provide data as to the usefulness of a yarn in weaving.

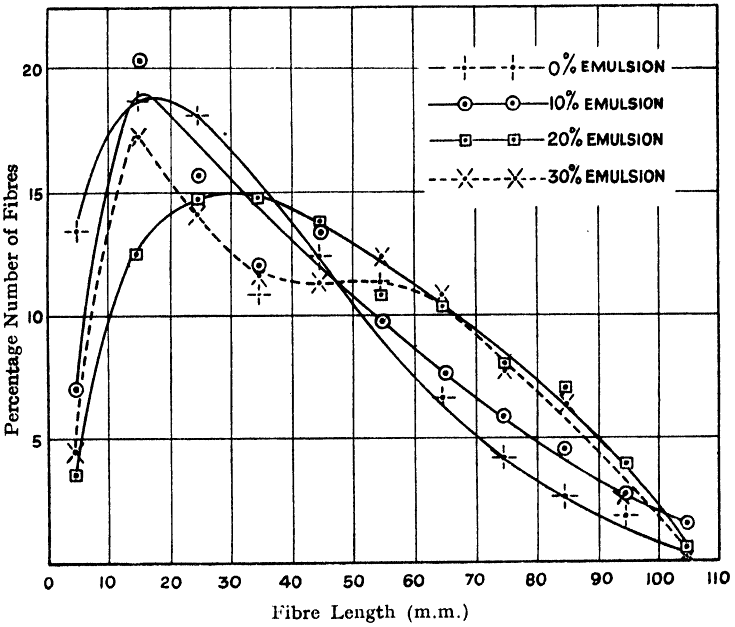

Fig. 2

The figures and graph relating to breaking load indicate that 20 per cent. emulsion is the maximum amount of lubricant necessary to obtain the strongest yarns, after which the strength gradually falls away. In commercial practice where the lots processed are considerably greater than those possible in experimental work, it does seem likely that a smaller amount of emulsion than 20 per cent. would be equally efficient, since there would be less loss of lubricant than that shown by Table II. At the same time it must be remembered that the greatest amount of fibre breakage takes place in the first part of the machine when the lubricant is more likely to be still on the wool and be utlised in preventing excessive breakage of fibres.

Table III.

Fibre Length m.m.	Percentage Number of Fibres in Slubbing oiled with :					
	0%	5%	10%	15%	20%	30% Emulsion
0—10	13·4	14·7	7·1	4·4	3·6	4·5
10—20	18·7	16·2	20·2	14·1	12·5	17·3
20—30	18·1	16·3	15·7	16·2	14·8	14·2
30—40	10·8	13·7	12·0	16·6	14·8	11·6
40—50	12·3	9·0	13·3	11·6	13·7	11·3
50—60	11·3	9·1	9·8	9·9	10·9	12·3
60—70	6·6	7·3	7·5	9·9	10·4	10·8
70—80	4·1	6·5	5·8	4·6	8·0	7·7
80—90	2·6	3·3	4·5	7·0	7·0	6·4
90—100	1·8	2·6	2·6	2·9	3·9	2·6
above 100	0·3	1·2	1·5	2·5	0·5	0·1
Mean Length m.m.	3·6	3·6	4·0	4·4	4·6	4·5

In order to obtain more information about the yarns, three Wilkinson tufts each containing approximately 200 fibres were prepared from samples of the condensed slubbings which had been preserved. The data obtained are given in Table III, whilst Figure 2 has been prepared to illustrate how fibre breakage varies with the different amounts of lubricant. It will be seen that the mean fibre length is almost in the same order as the breaking load corrected for count. The only exception is the lot which had no lubricant applied to it, but this is accounted for by the fact that this yarn must have had more fibres in its cross section, since it had less lubricant, and further, the fibres had very little lubricant on them to enable them to slide over each other in testing, so that friction had a greater influence on the test. Perhaps a better summary of the results for the 15 per cent., 20 per cent. and 30 per cent. lots is that the percentage number of fibres present in these lots measuring more than 40 m.m. in length was 48·4, 54·4 and 51·2 respectively. It thus appears that the strength of a yarn is dependent on the length of the fibres which go to make it up. The presence of the emulsion serves to preserve the fibre length up to a certain point, which in this case was 20 per cent. on the weight of the wool, but after that amount there is a gradual decrease in the strength of the resulting yarn. It is suggested that the reason for the deterioration in strength is due to the increased amount of water present in the lubricant which weakens the fibres and allows them to be more easily broken by the working action of the carding process. This is borne out by comparing the graphs of the 20 per cent. and 30 per cent. lots which show considerable divergence as regards the shorter fibres. Thus whilst water is useful in emulsion oiling in so far as it allows a better distribution of oil and therefore quicker processing, since there is more lubricant to spread over the same mass of wool, there is a limit to the amount which can be added, above which any further lubricating action due to the presence of the oil will be counterbalanced by the weakening effect of the water.

It is interesting to note that in commercial practice 20 per cent. emulsion is used on fine wool blends, which is another example of the practical man arriving at the same results by years of experience as the theorist.

SUMMARY.

The object of the experiment was to determine the critical amount of lubricant to be added to fine wool blends.

The wool used was 64's Queensland scoured merino.

The emulsions used consisted of 50 per cent. oleine and 50 per cent. water.

The maximum amount of lubricant which can safely be added for maximum yarn strength is 20 per cent. emulsion.

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4—THE IMPROVEMENT OF CHINESE AND OTHER CARPET WOOLS

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Carpet wools are produced by sheep which run under primitive conditions through all parts of the world. The wool is composed of a mixture, a long, hairy outer coat protecting the finer undercoat of true wool which keeps the animal warm. This type of fleece protects the sheep from severe weather conditions with low temperatures, high winds, and extremes of moisture conditions running from extreme dryness to excessive rain and fog. These two types of fibres make up the main part of the carpet wool fleece, but a third type of fibre, the so-called kemp, also occurs in varying amounts. This is a brittle opaque fibre which is easily identified. All degrees of variation between these three types of fibres are found, and when these wools are analyzed macroscopically several sub-types of fibres have been distinguished under each type.

A large proportion of the carpet wool produced comes from the Asiatic countries, and the preponderance of the sheep from which these wools come are of the fat-tailed and broad-tailed varieties, although some of the carpet wool producing sheep are of the thin-tailed varieties.

Short Review of Literature

European Breeds Producing Carpet Type Wools. Blyth (1923) made an analysis of two fleeces from Scotch Blackface sheep. She found a difference in the shoulder and britch samples in regard to the various types of fibres present. The estimation of the different types of fibres by count showed 71 per cent. wool and 29 per cent. hair and kemp in the shoulder sample and 59 per cent. wool and 41 per cent. hair and kemp in the britch sample. The kemp alone amounted to 5 per cent. in the shoulder and 9 per cent. in the britch. Blyth made measurements of the thickness of the different types of fibres and reports 28 microns for wool and 76 microns for the hair of one fleece and 31 microns for wool and 58 microns for the hair of the second fleece.

Darling (1932) continued the studies of Scotch Blackface fleeces, and his analyses of fleeces from sheep of all ages showed 74 per cent. wool and 20 per cent. hair and 6 per cent. kemp by count. He also made an analysis by weight and found 42 per cent. wool, 52 per cent. hair, and 6 per cent. kemp. Lochner (1931) made an analysis of Scotch Blackface wool from lambs, studying the development of the different types of fibre at different ages of growth. He began his study with samples from week old lambs and continued the work at weekly periods up to 17 weeks and fortnightly after that time up to 33 weeks. There is a gradual increase in the amount by count of the wool fibres from 57 up to 80 per cent., while the long hair decreases from 24 to about 10 per cent. The amount of kemp steadily increases from 4 weeks of age, when it first appears, up to 33 weeks, when it is roughly 11 per cent.

Bryant (1933) made a study of the inheritance of kemp in the Scotch Blackface breed and found that kemp was definitely inherited through certain sires. Rams showing less than 1 per cent. of kemp in their fleeces have greater numbers of progeny which show approximately this percentage of kemp than progeny from more kempy rams.

Bulgaru (1935) made a study of the fleeces of white Turcana sheep, which are a Roumanian breed, of the Zackel type. He found in this breed that there were 75 per cent. of wool fibres and 25 per cent. of hair and kemp by count. He further divided the hair into medullated and non-medullated, and the medullated fibres were slightly thicker than the non-medullated ones. He found that the wool fibres in these fleeces showed a thickness in direct proportion to their length, and became coarser as they increased in length.

Russian and Chinese Breeds Producing Carpet Type Wools. Balmont and Ermekov (1935) made a study of the Degeres sheep, which is the result of crossing Kazakstan fat rumped ewes with Shropshire rams. The fleece of these sheep consists of 77 per cent. by weight of wool, with a fibre thickness of 25 microns, and 23 per cent. by weight of hair with a fibre thickness of 35 microns. Kemp is rare or absent.

Diomidova and Muruev (1935) report on the Buriat Mongolian sheep and its crosses with the Merino. The native sheep of Buriat Mongolia are probably descended from distant crosses of fat-rumped and thin-tailed sheep. The fleece consists of 81 per cent. wool, 17 per cent. hair, and 2 per cent. kemp. When crossed with imported Rambouillets the fleece was improved in regard to fleece weight (from 2·5 to 5 pounds), and the amount of hair was slightly increased while the kemp was eliminated and the wool remained practically the same. Measurements of thickness were made on a number of fibres and gave the following results: Wool 19·8 microns, hair 39·0 microns and kemp 59·4 microns.

Munz (1937) analyzed a number of wool samples originating in North Eastern Asia. Thirteen wool samples from Thibet, China, and Inner Mongolia were scoured and analyzed. All these samples consisted of an outer coat of long hair and kemp and an inner coat of fine wool. The percentages by count for the 13 samples ranged from 12 to 22 per cent. of hair and kemp with an average of 17·2 per cent. The amount of pure wool varied from 78 to 88 per cent. with an average of 82·8 per cent. One other sample of Shantung lamb wool contained only 2·4 per cent. of hair and kemp and thus was not comparable with the other samples. The measurements of the under coat (wool) showed a range from 10 to 50 microns with an average of 22·5 microns. This corresponds to 64's quality, but is too uneven for good spinning. No measurements were made of the overcoat (hair and kemp). The 13 samples were from four different regions. The 4 samples of Mongolian wool showed an average by count of 82·3 per cent. wool and 17·7 per cent. hair and kemp. The 3 samples of Thibetan wools showed an average of 81·3 per cent. wool and 18·7 per cent. of hair and kemp. The 4 samples of Kansu wools, which are similar to Thibetan, showed percentages of 82·8 per cent. wool and 17·2 per cent. of hair and kemp. The 2 samples of Shanshi and adjacent Shensi contained 85·5 per cent. wool and 14·5 per cent. of hair and kemp. Although the Sining (Thibetan) and Mongolian wools both showed under wool of fine spinning count (60's to 70's) the wools lacked spinning quality because of their unevenness. The harsh feel of the Mongolian wools is due to the amount of hair and kemp.

Saito (1936) worked with Mongolian wools. He made a classification of these wools based on macroscopical characters and divided them into three types:—1. Fine type (wool) round or elliptical in cross-section, cortex complete and no medulla ; 2. Semi-coarse type (hair and heterotype) round or elliptical, rarely rectangular ; medulla small, occupying one-sixth to one-third of cross-sectional area ; no air inclusions in medulla ; 3. Coarse type (kemp?) irregularly round and elliptical in shape ; medulla very wide occupying from one-third to two-thirds or more of cross-sectional area ; 4. True kemp ; round in shape ; medulla occupies almost all the cross-sectional area and shows as a network of air chambers ; the cortical area is very thin and takes up about one-twentieth of total cross-sectional area. This classification approaches closely that used by Darling and others at Edinburgh in which kemp, heterotypes, and hair were distinguished from true wool.

The wool from the Mongolian fleece consists of 22·2 per cent. of coarse wool, including kemp (average thickness 90 microns), 8·6 per cent. semi-coarse type (average thickness 42·5 microns) and 69·2 per cent. fine type (average thickness 25·5 microns). The percentages are by weight.

Practically all of the Chinese wools have a high percentage of hair and kemp fibres due, no doubt, to the harsh conditions under which the sheep live in cold climates and on poor soil. Rasmussen (1936) gives a description of the different types of Chinese wools. Many attempts have been made to improve the Chinese sheep by crossing with various improved breeds, but these experiments were generally failures due to the fact that the improved sheep could not stand the natural pasturing conditions and must have shelter and feed.

Because of these conditions two methods of improvement are open:—1. through the use of improved breeds under conditions where shelter and some additional forage are available, and 2. through the use of selected native sires where the sheep must be run under natural forage and climatic conditions. The object of the first method is to obtain more uniform fleeces of improved wool type while the object of the second method is to obtain sheep which will stand the natural conditions and give suitable fleeces of mixed wool type. The first method has been tried for a number of years and is suitable under certain conditions. The second method has not as yet been tried, and since the climate of the larger part of the pastoral area of China is generally too severe for the improved European sheep or their crosses, and since there is a well established market for the mixed wool of the native sheep for the manufacture of carpets, it seems that the improvement of the fleeces of the native sheep by selection within the mixed wool type is the most desirable course to follow both from the standpoint of the safety of the animals in resisting harsh climatic conditions and the certainty of holding and expanding a known market which looks to China to furnish carpet wools.

Vicanere and Aleppo wools are considered as among the best carpet wools in the world by carpet manufacturers, and the Thibetan is supposed to be the best among the Chinese wools. The Vicanere wool is not only soft but also very lively and springy. Mill men place liveliness and springiness high in the list of valuable characteristics of carpet wools. The Woozie is about the poorest carpet wool produced in China.

Before any programme of improvement of Chinese mixed wool types of fleeces can be undertaken, it is necessary to know what constitutes the desirable characteristics of carpet wools. Some measurements have been made of the fleeces of different types of mixed wool fleeces which have been reviewed in the first part of this paper. However, no samples have been picked with the idea of checking up on the relationship of macroscopical analysis of desirable carpet wools to their manufacturing quality.

With this object in mind, Mr. Chen in his graduate work in wool made a study of five samples of Chinese wools of different types and compared these five samples with Vicanere and Aleppo wools, which were considered by mill men to be ideal types of carpet wool. A sample of Romney marsh wool was also included in the study, as this type of improved wool is similar to the carpet types and is often used for this purpose.

Source of Samples

The samples were furnished by carpet wool dealers in Philadelphia and by carpet mills.

Description of Samples

1. True Sining wool is a type of Thibetan wool which is considered to be the best of all Chinese carpet wools. It is rarely obtainable to-day in its pure type.

2. Mixed Sining wool is a mixture of true Sining and Kansu wool.

3. Lanchow wool comes from the province of Kansu. It is often blended with Thibetan wools.

4. Szechuen wools come from the province after which they are named and are classed with Thibetan wools.

5. Woozie wools come from the neighbourhood of Shanghai and are short in staple and suitable only for filling wools in carpet making. They are known in the trade as one of the poorest carpet wools.

6. Vicanere wool is produced in north central India and is of the finest carpet wools. It is exceptionally lively and lofty.

7. Aleppo wool is grown in Syria, Asia Minor, and is considered to belong to the better class of carpet wools. It has good length and is well known for its colour, strength and resiliency.

8. New Zealand Romney wool is an improved type of wool similar in type to carpet wools but more uniform. It is included in this study to represent a type of improved wool suitable for use in carpet manufacture and is similar to the South American wools which are now furnishing a large part of the carpet wool imports to the United States.

Analytical Procedure

The wool samples were spread out on a table, and the locks were separated according to type. A proportionate number of locks were taken from each type, and these were made up as a representative sample which was used for analysis. It was necessary to be very careful in this separation in order to avoid breaking the closely packed and intertwined fibres. Half of each lock in the representative sample was scoured, and half left in the greasy condition. A small bundle of wool was taken at random from each half-lock of scoured wool, and the collection of these bundles made up the composite replicate samples. One composite replicate sample was picked at random, and all of the fibres in this sample were measured to determine their fibre length and thickness. At least three of the composite replicate samples were analyzed for fibre types. If the results did not check within reasonable limits, more replicate samples were analyzed. The actual number of replicate samples which were measured varied from four to seven.

The Fibre Types

Chinese and other carpet wools of mixed wool type consist of different varieties of fibre such as *true wool* (fine undercoat), *kemps* (usually lying loose in the fleece), *heterotypical fibres* (hair and intermediate fibres), and *coloured fibres.*

True wool refers to those fibres which make up the fine undercoat of the mixed wool sheep. These fibres are oval in cross-section, have a solid cortical mass making up the shaft of the fibre, show no medullation, and are usually quite fine. Even in fleeces of coarse appearance these *true wool* fibres of the undercoat may be of 64's to 70's spinning quality.

Kemps are the brittle fibres which are lying loose in the fleece, they are easily distinguished from the longer coarse medullated fibres which are not normally shed.

Table I. Characteristics of the Different Kinds of Kemp.

Characteristics.	Ordinary Kemp.	Flat Kemp.	Hybrid Kemp.
Average length in mm. ...	60·40	52·71	104·45
Average thickness in microns ...	27·94	29·38	37·66
Location	Inner coat.	Inner coat.	Proximal end in inner coat, distal end in outer coat.
Cross-sectional shape	More or less oval.	Long and narrow horseshoe or dumb-bell shape.	Irregular.
Medullation under microscope...	All dark.	Dark on margins. Transparent in middle.	All dark.
Breaks or transverse bends ...	Very few.	Many.	Very few.
Form of fibre shaft	Straight.	Waved.	Straight.
Occurrence	Very few.	Very numerous.	Numerous.

The ordinary kemps were more or less similar to the hybrid kemps, but it was relatively easy to distinguish the ordinary kemps, because they are scarce and much shorter and finer than the hybrid kemps. The flat kemp is very easy to distinguish because of its ribbon-like form and its peculiar cross-sectional shape.

Heterotypical fibres, as the name implies, are neither wool nor kemp. Originally the name was applied to those fibres which showed within the same fibre shaft the characteristics of wool fibres, kemps, and hairs. Later as the kemps were divided the name came to be applied to those fibres which showed the fibre shaft characteristics of both wool and hair in the same fibre, particularly in respect of medullation and non-medullation. The structure of heterotypical fibres, as shown in the cross-sections, may vary considerably from the proximal to the distal end.

Coloured fibres varied from pale yellow to black in the true wool. In the kemps the colour varied from black to red or fawn and on to yellow or buff. A great amount of variation in colour exists, even in the same fibre.

Separation of Fibre Types. The sub-samples were placed on a black velvet pad and the fibres were separated by tweezers. Entangled fibres were loosened by means of a pin. The heterotypical fibres (all long, hair-like, flexible fibres) were separated first, and then the kemps were taken out. Any fibre of doubtful type macroscopically was subjected to the benzol test or microscopically examined. The number of fibres of each type was counted during the separation of the different types, and the results calculated as percentages of the total number of fibres in the sample. The percentages of the different fibre types were determined first by percentage by number and then by weighing the fibres of different types and calculating the percentages by weight. The weights were taken in the air dry condition on an ordinary balance.

Measuring Instruments Used

A micrometer caliper graduated in ten-thousandths of an inch was used to measure fibre thickness. A steel rule and a chenille rug swatch with deep pile, with a special pair of tweezers, were used to measure fibre lengths (*Wyoming Agricultural Experiment Station Bulletin* 204).

Fibre Measurement

The fibre thickness and length were obtained by measuring 300 fibres from each fibre group. Three portions of each fibre were measured, the proximal, distal, and middle, and the average of these three measurements was recorded as the thickness of the fibre. The number of fibres used in the analysis for fineness and length was the same for the true wool fibres, 300 being measured for fineness and length. However, there were not enough of the other fibres in a single sample to make up as many as 100 fibres in some cases, so the measurements were made after all of the samples had been analyzed for fibre type.

Table II. Numbers of Composite Replicate Samples and Fibres Used in Carpet Wool Analyses.

Wool Type.	No. of samples.	Number of Fibres used.			
		For type analysis.	For fineness and length.		
			Wool.	Heterotype.	Kemp.
Romney	1	500	500	—	—
Lanchow	5	7,783	300	200	100
True Sining	4	4,163	300	278	—
Szechuen	7	10,493	300	300	272
Mixed Sining	5	3,286	300	176	275
Woozie	7	16,816	300	—	300
Aleppo	6	4,473	300	300	119
Vicanere	6	11,298	300	300	—

In calculating the percentage of each fibre type by count it was necessary to carry the figures to the second decimal place in order to have sufficient decimals to take care of the smaller number of kemp and coloured fibres which were found in some samples.

The Analysis of Carpet Wools

It has already been pointed out that carpet wools are of the mixed wool type and consist of a mixture of true wool, hair, including heterotypical fibres, and kemp. If the carpet wools which are considered the best by the carpet manufacturers gave a macroscopical analysis markedly different from those which were not in such esteem, a large part of the problem of setting up an ideal carpet wool type would be solved. The importance of setting up an ideal mixed wool type keeping in mind the hardiness required in the sheep for grazing under natural conditions has already been mentioned.

The Quantity of Pure Wool in the Various Carpet Wools. The percentages by count of true wool fibres in the different kinds of carpet wools in this study are shown in Table III.

Table III. Percentages, by Count, of True Wool Fibres.

Wool Type.	Percentage by count of true wool fibres.
Romney	100·0
Lanchow	91·03
True Sining	88·65
Szechuen	87·12
Mixed Sining	84·66
Woozie	83·72
Aleppo	74·69
Vicanere	59·22

The carpet wools which were esteemed by manufacturers had a much lower content of pure wool fibres by count than the other carpet wools. The Woozie wool, which is considered as the poorest carpet wool of all, had a medium content of true wool fibres. The Romney wool sample which was analyzed did not show any other type of fibre except true wool fibre. The best carpet wools generally had a much lower percentage by count of true wool fibres.

The Quantity of Hair and Heterotypical Fibres in the Various Carpet Wools. The carpet wools popular among the manufacturers showed larger quantities of hair and heterotypical fibres than did the other less desirable carpet wools. The percentages by count of hair and heterotypical fibres in the different carpet wools analyzed are shown in Table IV.

Table IV. Percentages by Count of Heterotypical Fibres.

Wool Type.	Percentage by count of heterotypical fibres.
Vicanere	40·67
Aleppo	18·87
True Sining	9·15
Lanchow	5·88
Szechuen	5·80
Mixed Sining	3·93
Woozie	0·00
Romney	0·00

The Quantity of Kemp in the Various Carpet Wools. There was a very small amount of common kemp in the samples analyzed, and hence the percentage of kemp as herein reported includes both the flat and hybrid kemps. The carpet manufacturers do not want a very high percentage of kemp in the wool which they are processing. The more desirable carpet wools had a low percentage of kemp fibres by count, as shown in Table V.

Table V. Percentages by Count of Kemp.

Type of Wool.	Percentage by Count of Kemp.		
	Flat and common.	Hybrid.	All Kemp.
Vicanere	0·11	0·00	0·11
True Sining	0·12	0·00	0·12
Aleppo	2·44	0·42	2·86
Lanchow	2·21	0·87	3·08
Szechuen...	6·17	0·90	7·07
Mixed Sining	7·52	3·83	11·35
Woozie	15·26	1·01	16·27

It will be noted that the Woozie and Mixed Sining, which are less highly esteemed as carpet wools than the others, both carry a large quantity of kemp. The kemp is brittle and slippery and thus does not hold up or hold together in the carpets.

The Quantity of Coloured Fibres in the Various Carpet Wools. The quantity of coloured fibres varies too widely within a given type of carpet wool to permit the making of any but general observations. In the samples which were analyzed the Lanchow, Szechuen and Vicanere wools did not contain any coloured fibres. The highest number of coloured fibres was found in the Aleppo sample, which showed 3·58 per cent. by count. Other samples showed 2·09 per cent. for True Sining, Mixed Sining 0·06 per cent., and 0·01 per cent. for the Woozie wool.

The macroscopical analysis of carpet wools indicates that the more desirable types according to manufacturers contain lower percentages of true wool and kemp and larger percentages of heterotypical fibres. This relationship is shown in Table VI.

Table VI. Percentage of Different Types of Fibres by Count.

Wool Type.	*Ranking in Order of Desirability of Analysis.		
	True wool fibres.	Heterotypical fibres.	Kemp fibres.
Vicanere	1	1	1
Aleppo	2	2	3
Woozie	3	7	7
Mixed Sining	4	6	6
True Sining	6	3	2
Lanchow	7	4	4
Romney	8	8	8

* The assumption is that the lower percentages of true wool and kemp fibres and the larger percentages of heterotypical fibres are present in samples which are more desirable in the carpet mills.

The Vicanere and Aleppo wools, which the mills considered to be the most desirable, bear out this ranking when examined macroscopically. From the above table it appears that the proportions of heterotypical and kemp fibres have a closer bearing on their manufacturing qualities than does the quantity of true wool. Undoubtedly other factors such as length, strength and loftiness are concerned.

Counting and Weighing as Methods for Fibre Type Analysis. Much of the work on fibre type analysis of carpet wools has used the method of counting the number of fibres of each type of wool. However, the great difference in size between fibres of different types and even within the same type has had a marked effect on the percentages by count as compared with the figure obtained when the analysis is obtained by weight. It was thought advisable in working out this problem to make determinations of the percentages of each fibre type by counting and by weighing.

A comparison of the two kinds of analysis is shown in Table VII.

Table VII. The Percentages of Each Fibre Type in Carpet Wools, as Determined by Counting and by Weighing.

Wool Type.	Types of Fibres.							
	True wool.		Heterotype.		Kemp.		Coloured.	
	By count.	By weight.	By count.	By weight.	By count.	By weight.	By count.	By weight.
Lanchow ...	91·03	74·49	5·89	13·18	3·08	12·33	0·00	0·00
True Sining...	88·65	42·84	9·14	46·19	0·12	0·23	2·09	10·74
Szechuen ...	87·12	57·65	5·80	27·85	7·08	14·50	0·00	0·00
Mixed Sining	84·66	61·51	3·93	16·42	11·35	22·02	0·06	0·05
Woozie ...	83·72	55·56	0·00	0·00	16·27	44·37	0·01	0·07
Aleppo ...	74·69	43·82	18·87	52·30	2·86	3·15	3·58	0·73
Vicanere ...	59·22	23·23	40·67	76·67	0·11	0·14	0·00	0·00

The differences in percentages as determined by the two methods of determination range from 16 to 45 per cent. in true wool fibres, from 0 to 37 per cent. in heterotypical fibres and from 0·3 to 28 per cent. in kemp fibres and from 0·01 to 8·65 per cent. in coloured fibres. Generally speaking the wool fibres are lighter, while the heterotypical and kemp fibres are heavier. Coloured fibres may be fine or coarse, and thus the size of the fibres must be taken into consideration in connection with fibre type analysis. It seems advisable to use both methods for each has its distinctive usefulness. The weights are useful not only in obtaining the percentages of different fibre types by weight but also in obtaining a weighted figure for fibre fineness through the weight-length ratio. This is a particularly useful determination in the case of heterotypical and kemp fibres, where the fineness measurements often vary so widely at different parts of the fibre shaft.

Fibre Thickness and Length of True Wool Fibres. The measurement of true wool fibres from the different types of wool used in this study gave the results shown in Table VIII.

Table VIII. Fibre Thickness and Length in True Wool Fibres.

Wool Type.	Thickness in microns.		Stretched length in mm.	
	Mean.	Coefficient of variability.	Mean.	Coefficient of variability.
Romney	31·99	18·91	218·70	21·32
Aleppo	23·96	24·50	137·30	21·27
Szechuen	20·64	19·70	120·63	35·42
Lanchow	19·56	44·85	107·83	37·00
True Sining	17·51	22·79	110·00	30·26
Mixed Sining	17·43	26·97	79·40	45·04
Vicanere	17·41	19·85	72·00	23·89
Woozie	16·29	21·22	71·00	44·37

The best carpet wools probably do not owe their inherent qualities to the fibre thickness or length of the true wool fibres. As already pointed out, the best carpet wools show the least amount of true wool fibre. However, it is interesting to note that the fibre thickness of the finest of these wools would classify in the Half Blood grade, but variability of fibre thickness, as indicated by the coefficient of variability, is much greater than the figure of 15 per cent. which has been set as a maximum allowable variability in well bred wool sheep.

Fibre Thickness and Length of Heterotypical Fibres. The measurements of heterotypical fibres from the different types of wool are shown in Table IX.

Table IX. Fibre Thickness and Length in Heterotypical Fibres.

Wool Type.	Thickness in microns.		Stretched length in mm.	
	Mean.	Coefficient of variability.	Mean.	Coefficient of variability.
Aleppo	41·06	11·08	218·80	15·36
True Sining	36·34	10·42	213·71	22·24
Szechuen	33·25	8·10	211·80	10·85
Mixed Sining	32·40	17·49	195·60	41·92
Vicanere	25·73	18·18	117·00	21·88
Lanchow	21·12	38·51	102·20	27·89

The quantity of heterotypical fibres in a sample seems to be closely associated with its value for carpet weaving. The variation in stretched length seems greater in the samples which are made up of a mixture of other types. It is generally known in the trade that Mixed Sining as well as Lanchow are often mixtures of different types. The Aleppo type shows heterotypical fibres with great thickness and rather uniform thickness from fibre to fibre. These fibres also show a very uniform and long fibre length. So from the standpoint of fibre thickness and length of the heterotypical fibres, the Aleppo sample is outstanding. The heterotypical fibres in practically all samples were much more uniform in fibre thickness and length than were the true wool fibres, a point which is probably very important in carpet wool type. Of course, the poorest carpet wool type, namely Woozie, did not contain heterotypical fibres.

Fibre Thickness and Length in Kemp Fibres. The measurements of fibre thickness and length of the kemp fibres are shown in Table X.

Table X. Fibre Thickness and Length in Kemp Fibres.

Wool Type.	Thickness in microns.	Stretched length in mm.	
	Arithmetic average 3 parts of fibre.	Mean.	Coefficient of variability.
Aleppo	39·64	51·00	63·10
Woozie	29·90	33·50	24·48
Mixed Sining	28·43	60·00	28·17
Lanchow	27·52	49·70	13·28
Szechuen	25·83	67·63	43·32

The kemp fibres are objectionable in any wool, and their relative size and uniformity probably have little influence. The fibre density and strength of these fibres probably has more importance, and when these figures are high the fibres probably closely approach to the heterotypical fibres in general characteristics.

CONCLUSIONS

It will be noted that the Chinese wools were generally not as good as the Vicanere and Aleppo wools in macroscopical characteristics. The Vicanere and Aleppo wools were used as a standard of comparison because these two types had been selected by carpet wool dealers and mills as the more desirable carpet wools. The Romney wool sample which was analyzed showed only true wool fibres. Thus it is hard to compare it with the other samples, which are all classed as mixed wools.

The primary object of this study was to consider the possibility of making up a guide for carpet wool producers based on objective tests in the laboratory on samples of carpet wools which had been evaluated as to their commercial value for manufacturing carpets by carpet wool dealers and mills.

Certain very definite relationships were found between objective tests in the laboratory and subjective tests by dealers and mills and these relationships have been incorporated in the following tentative guide of wool type for carpet wool producers.

Tentative Guide of Wool Type for Carpet Wool Producers

1. An ideal carpet wool should contain at least 15 per cent. by count or 35 per cent. by weight of heterotypical fibres. These fibres should have an average thickness of at least 30 microns, and the fibre sizes should not vary more than 15 per cent. The average length of these fibres should be at least 100 mm. for normal growth (12 months), and the variability of the fibre length should be less than 20 per cent.

2. An ideal carpet wool should contain not more than 2 per cent. by count or 4 per cent. by weight of kemp fibres. The dimensional characteristics of the kemp fibres are not so important. The important thing is to eliminate kemp from the fleeces, and this can be done, according to the experimental work carried out by Bryant (1933) working with Scotch Blackface sheep.

3. An ideal carpet wool should contain not more than 85 per cent. by count or 65 per cent. by weight of true wool fibres. These fibres should have an average thickness not exceeding 25·4 microns, and their variation in fibre thickness should not exceed 25 per cent. They should have an average length of at least 100 mm. for normal growth (12 months), and the variation in fibre length should not exceed 25 per cent.

SUMMARY

Some of the different types of carpet wools are described as to their characteristics and origin.

Samples of desirable and undesirable carpet wool samples were collected from carpet wool dealers and mills, together with their opinions as to the relative value of the different samples.

Seven samples of carpet wools and a sample of Romney wool were analyzed microscopically and macroscopically, for fibre types, fibre thickness, and fibre length.

A tentative guide of wool type for carpet wool producers was formulated.

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TRANSACTIONS

5—THE EXAMINATION OF DAMAGED COTTON BY THE CONGO RED TEST: FURTHER DEVELOPMENTS AND APPLICATIONS

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I. INTRODUCTION

Since the publication in 1926 of a description of the Congo Red staining method[2] the test has been in constant use at the Shirley Institute. Further observations have been made on the appearance of damaged and treated fibres stained by this method, and it is considered that the publication of the further results and details of technique may enable the method to be used by many engaged in textile research, particularly those who are called upon to differentiate between the various types of tendering occurring in cotton yarns and cloths.

Perhaps it is advisable to say at the outset that the test is of a type that is not particularly familiar to chemists and physicists although it is common in biology. The essential difference between it and the common chemical test is that the result of the latter is a statistical figure expressing the average behaviour of very large numbers of atoms or molecules whereas the Congo Red test, in common with most biological tests, is a record of observations on a few individuals, which, as is usually the case with biological units, may differ considerably from each other. The high degree of precision possible in chemical tests is therefore unattainable and the value of the Congo Red test is dependent on the experience of the observer and his ability to recognise particular features of microscopic appearance of a comparatively few individual cotton fibres. However, the appearances characteristic in this test of various forms of damage are in general so distinctive that the experience necessary for its use is not difficult to gain.

Some description of the swelling phenomena of the cotton fibre upon which the Congo Red staining method is dependent, together with a more explicit description of the technique is given for the benefit of those observers who wish to use the test but are not familiar with the structure of the fibre and its behaviour during swelling.

II. BASIS OF THE TEST

The Congo Red test is based upon:

1. The different rates of diffusion, at room temperature, of direct dyes into the exposed secondary cellulose and the cuticle of the cotton fibre, after swelling in caustic soda, with the result that the former is stained to a deeper shade.

2. The behaviour of the cotton fibre when swollen with caustic soda solution particularly with regard to the constricting action of the cuticle.

3. The spiral splitting of the cuticle.

1. Staining.

Cotton fibres that have been swollen with caustic soda solution, washed with water, and stained with Congo Red are not uniformly coloured; where the cuticle has been damaged or the secondary cellulose exposed at a base or broken end of the fibre the stain is taken up more rapidly, so that, while the cuticle stains only a faint pink, the exposed secondary cellulose becomes bright red. Many of the direct cotton colours behave similarly but Congo Red possesses the advantages of showing the effect in well-pronounced manner and permitting the remounting of stained fibres in concentrated caustic soda solution without immediate fading of the colour—an essential requirement of the testing method. It should be noted that the extent to which differential staining occurs depends both on the temperature and the time. If the staining is carried out for a long time at 100° C. there is no differentiation, both the cuticle and secondary cellulose being deeply stained. Staining tests on preparations for the microscope are, however, almost invariably carried out at room temperatures, and in this condition different depths of shade are acquired by the cuticle and the secondary cellulose.

2. Swelling in Caustic Soda Solutions.

Immediately before the ripe boll bursts the cotton fibres are tubular in form and taper to the tip, the cross section being approximately circular, with a skin or cuticle* on the surface with cellulose laid down inside, and a central canal or lumen. When the boll opens and the fibres are exposed to the atmosphere they collapse into the flattened and convoluted form of the cotton fibre as found in the bale. Calvert and Summers[8] state that the process of collapse and convolution is accompanied by shrinkage in the perimeter of the cross section and decrease in thickness of the cellulose wall, with consequent modification of the size of the lumen. In addition to the shrinkage on drying, they investigated the phenomena of swelling in caustic soda, and the following is a summary of their findings.

When a dried, collapsed fibre is immersed in 18 per cent. caustic soda solution the secondary cellulose swells, first filling the lumen and then exerting pressure on the cuticle until the original perimeter is regained; at the same time there is a shrinkage in length. It is important to note that the original form of the uncollapsed fibre has *not* been recovered, for it has been necessary to swell the secondary cellulose to a much greater wall thickness than it had in its fresh uncollapsed state; it appears, therefore, that it has been necessary to exert pressure on the cuticle in order to bring the fibre back to its original diameter.

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* "Cuticle" is used not in the strict botanical sense but includes primary cell wall and cuticle proper.

The effect of the concentration of the caustic soda solution used is as follows: In solutions of concentration up to about 7 per cent. there is a change of shape of cross section but no measurable swelling of the wall. In concentrations between 7 and 11 per cent. the wall thickness increases and the swelling proceeds in the inward direction, and at a concentration of about 11 per cent. pressure is exerted outwards on the cuticle, which attains its maximum extension in 13·5 per cent. solution. Solutions more concentrated than this do not increase the fibre width on account of the constricting action of the cuticle. The behaviour in concentrations up to 37 per cent. is shown graphically in Fig. 1, which is reproduced from the paper by Calvert and Summers.

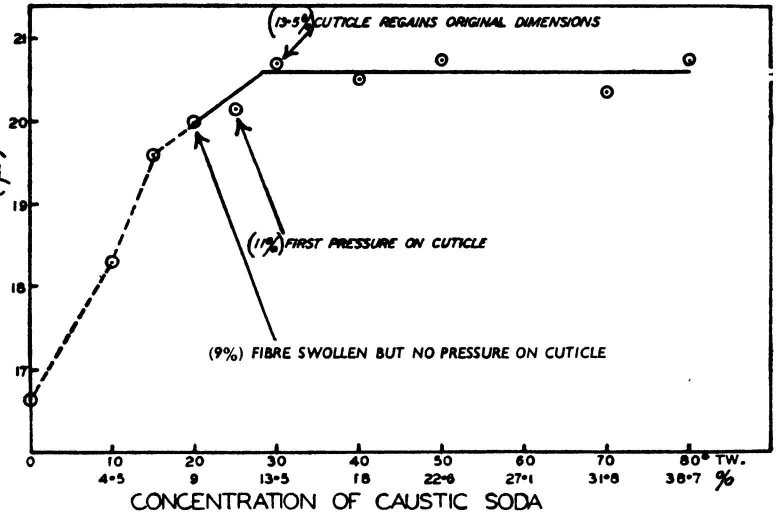

FIG. 1.

This description of the swelling is based on the examination and measurement of large numbers of fibres. The results have been considered statistically, and may be accepted as the behaviour of an average cotton fibre, i.e. an undamaged fibre with a normal degree of thickening. Any sample of cotton, however, contains fibres differing widely in wall thickness, and since the degree of thickening and the increase in wall thickness on swelling and the consequent pressure on the cuticle, play a significant part in the test, it is necessary to know something of the effect of the variation in wall thickness on the swelling of the fibre.

For investigating this point fresh cotton fibres from plants grown in the Shirley Institute greenhouse were allowed to collapse, and after the convolutions had been mapped, the fibres were swollen in 18 per cent. caustic soda—a strength sufficient to ensure complete swelling—washed and stained in Congo Red. The following observations were recorded:

i. Fibres that are normally convoluted, i.e. have a normal degree of thickening, become cylindrical on swelling and stain a faint pink.

ii. Fibres with a subnormal degree of secondary thickening, and therefore having few or no convolutions, remain or become convoluted on swelling and also stain a faint pink.

iii. Fuzz fibres and fibres with few or no convolutions consequent upon an abnormal degree of thickening show a spiral staining; Plate I, 2, 3, 4. (The behaviour of the three types is discussed quantitatively in the Appendix.)

3. Spiral Splitting of the Cuticle.

Examination of the spiral under high magnification shows that it is due to rupturing of the cuticle (Plate I, 4) and to subsequent staining of the exposed secondary cellulose (Plate I, 3). Swelling of untreated and apparently undamaged fibres in various strengths of caustic soda shows this splitting to occur only if the fibres are swollen with caustic soda of 11 per cent. and higher concentrations; very little splitting is present after swelling with 11 per cent. solution, but there is a fair amount after swelling with 18 per cent. solution. It is evident that the cuticle has a spiral line of weakness.

So far, consideration of the swelling and subsequent staining has been restricted to fibres that have had no previous treatment.

Observations on cottons that have been bleached, heat tendered, etc., show that these treatments result in a gradual breakdown of the cuticle which is shown by splitting into spirals that are coarse with mild treatments but become finer with increasing severity of treatment until finally no spiral structure is visible and the fibre stains uniformly red. (Plates II and III).*

In addition to these slow or " cuticle " spirals of the fibre there are two " quick " spirals resulting from heat, chemical or fungal tendering (Plate IV). These show on Congo Red staining, after preliminary swelling in 9 per cent. caustic soda, which solution is of insufficient strength to split the cuticle along the slow spiral. These quick spirals appear to follow the fibrillæ of the secondary cellulose. Balls[1] mentions structures that appear comparable and that stain with Naphthamine Blue. The observations recorded here would suggest that the quick spirals were originally connected with the collapsed convolution of the fibre, and that the fibre wall is weaker in this region.

III. TECHNIQUE

The sample of cotton to be examined is:

(*a*) Immersed for three minutes in a solution of caustic soda of definite strength which may contain a wetting agent, e.g. 0·5 per cent. Shirlacrol.

(*b*) Washed in water.

(*c*) Placed in a concentrated solution of Congo Red for 10 minutes.

(*d*) Washed.

(*e*) Immersed in 18 per cent. solution of caustic soda.

The purpose of the first immersion in caustic soda is to promote a controlled amount of swelling, and for this purpose different concentrations of caustic soda are used. The choice of concentration is of the utmost importance and is made in conformity with the swelling-concentration phenomena already described. Suppose that an examination is to be made for mechanical damage, say in an investigation to determine whether fibres are damaged by the "Licker-in" of a carding engine; if the fibres are actually damaged, the cuticle will be ruptured and the secondary cellulose already exposed, so that before staining with Congo Red it is only necessary to treat with 9 per cent. caustic soda. Furthermore, since at this concentration swelling is sufficient to close the lumen completely, and any further swelling will begin to stretch the cuticle and so tend to rupture it, a higher concentration must not be used. In seeking for mechanical damage, therefore, a 9 per cent. solution is used for the preliminary swelling.

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* These spirals are in fact the " slow " spirals of the fibre, and are at right angles to the convolutions and reverse in conformity with them : they are the pit spirals described by Balls[1] and explained by X-ray studies as principal planes of the crystal structure.

At a concentration of 11 per cent. pressure is exerted outward on the cuticle sufficient to cause spiral splitting of a cuticle weakened but not actually broken or torn; such weakening may be caused by heat, light, chemical attack, and mildew attack, and for examination for these forms of damage 11 per cent. caustic soda is used for the first swelling.

An 18 per cent. solution of caustic soda is used for the first immersion when weakness of the cuticle is likely to be slight, e.g. in examination for damage due to mild processing. It is used also where much swelling is required in order to rupture a cuticle not damaged by processing, e.g. in determining the percentage of abnormally thickened fibres.

A final immersion in 18 per cent. caustic soda is given to all the preparations and produces in the differentially stained fibres a final swelling which accentuates the colour contrast.

After the first immersion the material should be very thoroughly washed and the water removed by squeezing between filter papers, care being taken to see that no fibrous material is removed from the filter paper, and similar precautions must be observed in washing after immersion in the Congo Red solution.

For examination of the mounts it is advisable to use a ⅔-inch objective and 10 × eyepiece with daylight illumination. Critical illumination is not necessary, and the condenser is arranged so that the field is flooded, thus giving the maximum colour contrast. The mounts are only temporary, but can be made to last a few days if made air-tight by sealing with a cement composed of 20 per cent. lanoline and 80 per cent. colophony resin.[7]

IV. APPEARANCE OF FIBRES TENDERED OR TREATED IN VARIOUS WAYS

When the above procedure has been carried out the remainder of the test depends on ability to recognise the appearances typical of different treatments, and these appearances will now be described. Verbal description is, however, necessarily incomplete, and photographs scarcely do justice to the preparations as seen under the microscope. It must be emphasised, therefore, that before a correct interpretation of observations can be made on material of unknown history, experience must be gained of the use of the test by the examination of fibres that have been subjected to known treatments. Consultation of tables, or reference to photographs can never be used as substitutes for the knowledge that is gained by personal observation of these effects.

(a) Mechanical Damage.

Various forms of mechanical damage are shown in the Plates.

(i) Surface bruising, Plates I, 1, and X, 35. Only the cuticle has been damaged, and the swollen and stained secondary cellulose protrudes.

(ii) Deep cutting of the fibre wall, Plate X, 36.

(iii) Abrasion, Plates V, 19, and IX, 31.

(iv) Unbroken tips (X, 32), bases (X, 33), cut ends of fibres (V, 21), broken ends of fibres (V, 18).

Tests for damage in processing may be made quantitative by classifying and counting the damaged fibres. In one case, the proportion of bruised fibres rose from 20 per cent. in the bale to 36 per cent. in the yarn (100's Sakel); and a marked drop was found in the mean breaking load of the fibres in the yarn relative to those in the bale. Studies of this kind are, however, very laborious and have not yet been done with the thoroughness that would justify general conclusions on the amount of damage done in processing.

(b) Heat Tendering.

The gradual break up of the cuticle is well illustrated in Plate II, 5, 6, 7, 8, and 9, which constitute a series showing the effect of heat treatment for various lengths of time and at various temperatures. The cotton used was a Sakel, chosen because it showed evidence of very little damage in the raw state. The first stage is seen in the break up into very coarse spirals (II, 5). With increasing severity of treatment these break up into finer spirals, which gradually become so fine that the cuticle no longer exerts a constricting effect on the cellulose, until at last the fibres do not appear as cylinders but swell to a larger diameter, partially retaining their original convoluted form (II, 8). This is usually described as incomplete deconvolution. At the most extreme stage of heat tendering the cuticle becomes almost completely detached and the fibres stain uniformly bright red (II, 9). Some results of examination after Congo Red staining on cotton heated to various temperatures are recorded in Table I.

(c) Singed Ends.

These are very characteristic in appearance, Plate V, 22. After Congo Red staining, provided the extreme tip of the fibre has not broken off, the fibre ends are bright red and taper to a brownish red tip. Immediately adjacent to the bright red portion the fibre is split into spirals which extend only for a short distance and decrease rapidly in intensity. A singed yarn containing chlorides presents a rather different appearance, for then a fair length of the fibre stains a solid bright red which ends abruptly, an appearance indicating the chemical attack which is liable to occur when yarns containing chlorides are heated.

(d) Effect of Bleaching and Over-bleaching on the Cotton Fibre.

The appearance of bleached and over-bleached yarns is illustrated in Plate III, 10, 11, 12, and 13. A detailed examination after various processes was made on two cottons, both American, one in the form of loose cotton, A and B, and the other spun and woven into cloth, C. Table II is a key to the samples and treatments.

The cotton was sampled and stained with Congo Red after a preliminary swelling with 11 per cent. caustic soda: the results of the examination are given in Table III and photographs on Plate III.

Table I

Treatment	Effect
¼ hour at 150°C.	Simple spirals (Plate II, 5, 6)
24 hours ,, 110°C.	
24 ,, ,, 100°C.	
2 days ,, 95°C.	
6 weeks ,, 70°C.	
¾ hour ,, 150°C.	Fine spirals (Plate II, 7)
3 days ,, 110°C.	
5 ,, ,, 100°C.	
10 ,, ,, 95°C.	
2 hours ,, 150°C.	Fine spirals with incomplete deconvolution (Plate II, 8)
5–22 days ,, 110°C.	
19 ,, ,, 95°C.	Few fibres show incomplete deconvolution

Table II

Scouring treatment	Not chemicked	Chemicked with $N/25$ sodium hypochlorite at *p*H 7·0 for				
		¼ hr.	½ hr.	1 hr.	3 hrs.	5 hrs.
Caustic soda, 1%, for 6 hours at 30 lb. pressure	A	A_1	A_2	A_3	A_4	A_5
Water for 10 hours at 40 lb. pressure, followed by 2% caustic soda for 10 hours at 40 lb. pressure ...	B	B_1	B_2	B_3	B_4	B_5
Caustic soda, 1%, for 6 hours at 40 lb. pressure	C	C_1	C_2	C_3	C_4	C_5

Table III. Effects of Bleaching

Appearance	Treatment
1. Normal	Raw cotton and lint from grey cloth
2. Coarse spirals	A, C
3. Finer spirals (Plate III, 10)	A_1, C_1, C_2, C_3, C
4. Fine spirals with a few fibres showing incomplete deconvolutions (Plate III, 11, 12)	A_2, B
5. Fine spirals with incomplete deconvolutions (Plate III, 12)	A_3, A_4, B_1, B_2, B_3
6. Cuticle appears blotchy: many of the fibres red, sometimes with the cuticle hanging off (Plate III, 13)	A_5, B_4, C_5
7. Fibres red, cuticle hanging off	B_5

(e) Acid Tendering.

The cuticle goes through stages of splitting similar to those already described for heat tendering and over-bleaching, but the spirals are not so clear and the final stages show transverse cracking (Plate VIII, 29). Table IV gives the results of a series of tests on a Sakel cotton after treatment at 20°C. with hydrochloric acid, 200 gm. per litre, together with the fluidities in cuprammonium solution.

Table IV. Effects of Acid Attack

Duration of acid attack	Fluidity	Appearance
Untreated	—	Normal with an occasional spiral.
4 hours	15	Fine spirals with some incomplete deconvolutions.
16 ,,	28	Fine spirals, incomplete deconvolution, and blotchiness.
40 ,,	37	Fibres blotchily red with incomplete deconvolution and transverse fissures or cracks.

Local tendering by strong acid shows a bright red blotchiness after Congo Red treatment that is characteristic and easily recognisable (Plate VIII, 28).

(f) Light Tendering.

Light tendering results in a progressive splitting of the cuticle, but differs from heat tendering and over-bleaching in that when the damage has occurred in yarn or cloth the tendering is very localised. Fibres and parts of fibres that are on the surface and therefore exposed to the light show the effect to a much greater degree than do those in the centre of the yarn or cloth. Fibres may be present that show a marked degree of tendering over a distance of one millimetre, beyond which there is a quick transition to the appearance of the normal untendered fibre (Plate VI, 23, 24). It is not claimed, however, that light tendering could always be distinguished from heat or chemical tendering.

The Congo Red test was applied after swelling in 11 per cent. caustic soda to the warp of samples of a scoured warp-faced satin drill, the treatments and effects being recorded in Table V.

Table V. Effects of Light

Treatment	Appearance
Control, scoured.	Normal.
Cloth exposed for 140 hours to carbon arc with Vita-glass between the cloth and the arc ; 2·7% loss of strength.	A few fibres show very fine splitting—varying lengths of fibre. The effect is very localised.
Cloth exposed to carbon arc for 12 hours ; 47% loss of strength.	Fine spirals with localised red and powdery patches—these are the surface fibres of the yarn.
500 hours in bright sunlight ; 52% loss of strength.	Some fibres normal, some very fine spirals, a few fibres show bright red powdery regions.

(g) Mercerisation.

In fibres from well mercerised grey yarns the cuticle dyes a rather deeper shade than in fibres from unmercerised yarns, and there is some splitting into coarse spirals after a preliminary swelling in 11 per cent. caustic soda. Mercerisation may therefore accentuate the appearance of damage in those treatments that are typified by spiral splitting but the effect is small and does not make the appearances typical of the various forms of damage more difficult to recognise.

(h) Mildew Tendering.

Mildew (or fungal attack) affects the cotton fibre in various ways. When examined by the Congo Red method, after preliminary swelling in 11 per cent. caustic soda, there is occasionally an appearance similar to that of mechanical damage as in Plate VII, 25, but more commonly the effect is one of spiral splitting comparable in appearance with chemical damage; usually, however, there is a disintegrated appearance that distinguishes it from the latter. Occasionally, when the tendering is very pronounced, there is a tendency for the fibre to break up along the quick spirals (Plate IV, 15). The mildew hyphæ present often stain bright red under the treatment, and since the cuticle effect is usually localised and associated with the presence of hyphæ the evidence of fungal tendering is fairly conclusive. If, however, the material has been processed after attack and the hyphæ removed, other facts such as distribution of the damage and the fluidity in cuprammonium must be considered before conclusions are drawn. Conversely, it should be noted that when fungal tendering is suspected it is not sufficient to demonstrate the presence of the fungi, for many are incapable of attacking cellulose and may have grown on the size so that the specific form of tendering must be shown before fungal tendering can be regarded as established.

A series of Sakel cottons was inoculated with various fungi and tested for tendering. The results are presented in Table VI, which also gives the decomposing power of the organism on filter paper. With one or two exceptions there is a correlation between the Congo Red effects and the power of cellulose decomposition.

Table VI. Effects of Mildew

Fungus	Results of Congo Red examination
CELLULOSE-DECOMPOSING POWER, NIL :—	
Rhizopus, Record 85*	No effect.
Aspergillus Tamerii	
CELLULOSE-DECOMPOSING POWER, MODERATE :—	
Penicillium 2*	After preliminary swelling in 18% NaOH, irregularly damaged cuticle.
Aspergillus 46*	No effect.
,, 45*	No effect.
,, *Niger* 8*	Fine multiple spirals, some fibres bright red.
,, *Niger*	Fine multiple spirals, bright red.
Aspergillus 61*	Coarse spirals.
Record 83*	Bright red with incomplete deconvolutions.
CELLULOSE-DECOMPOSING POWER, STRONG :—	
Aspergillus 48*	Bright red with incomplete deconvolutions.
Penicillium 42*	Bright red with incomplete deconvolutions.
Fusarium	Bright red, splitting along quick spirals.
Fumigatus	Bright red, incomplete deconvolutions.

* These numbers refer to cultures in the Shirley Institute collection, 1935-36.

(j) Bacterial Tendering.

Some forms of bacterial tendering produce a very characteristic appearance which differs widely from any other type of tendering: the horizontal fibre in Plate VII, 26, is an example of this type. In other cases, however, the tendering is indistinguishable in the Congo Red test from that due to mildew and the distinction must be made by other means—e.g., by the standard staining tests for mildew and bacteria.

In concluding this section it may be useful to summarise the distinguishing features of the various types of tendering which may be classified as (i) mechanical, (ii) chemical (including heat and light), and (iii) biological.

(i) Mechanical tendering is sufficiently obvious to be easily recognisable and can be distinguished from chemical and biological tendering. Some forms of fungal tendering, however, except for the presence of the hyphæ, are similar in appearance to mechanical tendering. The various forms of mechanical damage—cutting, abrasion and bruising—are usually distinguishable from each other.

(ii) Chemical tendering, whether by heat, over-bleaching or acid, results in a gradual breakdown of the cuticle, shown by a splitting into spirals. The effect is similar in all cases and these three forms of damage are indistinguishable, with the exception of strong acid tendering which results in a characteristic bright red blotchiness. Light tendering exhibits similar features to the other forms of chemical tendering but if it has occurred on the yarn or cloth it may be identified by the localisation of the tendering to the surface fibres or portion of these fibres.

(iii) Biological tendering, whether by mildew or bacteria, may bear a general resemblance either to mechanical or to chemical tendering, but the disintegrated appearance of the fibres and tendency for the fibres to break up along the quick spirals, together with the presence of hyphæ or bacteria are distinguishing features.

V. GENERAL USES OF THE TEST

(a) Determination of the Number of Abnormally Thickened Fibres.

The splitting of the cuticle of abnormally thickened fibres after swelling with 18 per cent. caustic soda solution has been used to modify the immaturity test.[5] The procedure is as follows. The fibres to be tested are mounted on a slide, the ends being fixed by means of adhesive plaster, and treated with 18 per cent. caustic soda solution, the excess being removed by means of filter paper. Distilled water is then dropped carefully on the fibres and removed by means of filter paper, the process being repeated until all traces of the swelling liquor have been removed. The fibres are next stained with a saturated solution of Congo Red for ten minutes, washed again in distilled water, and finally mounted under a coverslip in 18 per cent. caustic soda solution. A count is then made as in the immaturity test with the modification that the rod-like fibres are differentiated into not split and split fibres, i.e., normal and abnormally thickened fibres. A particular application is described in the Appendix.

(b) Examination of "Dead" Cotton.

Dead cotton due to the attack of fungus on the cotton while it is growing in the boll, stains bright red in the Congo Red test and can thereby be differentiated from that due to other causes, genetic or physiological, which stains a faint pink only. (Plate VII, 27).

(c) Detection of Mechanical Damage due to Processing.

Mechanical damage may be expected in ginning and in the preparation for spinning, and the method has been used to investigate the amount of damage in these processes and in the actual spinning where the possibilities of damage are much less obvious. Cambodia cotton was spun into yarn and samples were taken:

(*a*) from the boll,
(*b*) after ginning and baling,
(*c*) from the finished lap,
(*d*) from card sliver,
(*e*) from roving,
(*f*) from twist yarn, 34's, Mule spun, and from weft yarn, 28's, Mule spun.

These were sampled and stained by the Congo Red method after a preliminary treatment with 9 per cent. caustic soda. The treated sample was placed at one end of the microscope slide and single fibres were drawn out and examined separately. These were classified as

(*a*) Normal, undamaged.
(*b*) Cracks associated with the presence of abnormalities (Plate X, 34).
(*c*) Bruised—cuticle rubbed, secondary cellulose protrudes (X, 35).
(*d*) Torn—secondary cellulose torn and stained (X, 36).

The results are set out in Table VII.

Table VII. Examination of Cotton for Damage in Spinning Processes

Source	Total number of fibres	Normal fibres	Fibres with abnormalities showing cracks	Bruised	Torn	Total fibres % damaged
Boll	250	174	63 25·2%	8 3%	5 2%	5
Ginned and baled ...	250	160	25 10·0%	40 16%	19 8%	24
Opener and scutcher ...	250	141	32 12·8%	35 14%	24 10%	24
Card sliver	250	104	49 19·6%	61 24%	28 11%	35
Roving	250	87	50 20·0%	69 28%	32 13%	41
Twist yarn	250	72	29 11·6%	121 48%	27 11%	59
Weft yarn	250	53	40 16·0%	121 48%	23 9%	57

The "Boll" Cambodia cotton was taken from some untouched bolls sent by the Indian Central Cotton Committee for exhibition purposes, and although of the same type, was not identical with the cotton in the processed samples.

There does not appear to be any significant difference between (*a*) the ginned and baled samples and the open and scutched, or between (*b*) the card sliver and the roving. The results suggest that most of the damage was done during ginning and baling, carding, and spinning. In this particular instance ginning and baling have been responsible for bruising or tearing about 18 per cent. of the fibres, carding for about 11 per cent., and spinning for about 23 per cent. The spinning process produced little tearing but a large amount of surface bruising.

These results are reported here merely to illustrate the method of investigation. A study of the damage to fibres done in spinning cottons of various types and sufficient to justify general conclusions is beyond the scope of this paper.

It may be noted that fibres pulled down from a number of hard-twisted sewing cottons showed a very large amount of surface bruising in which a spiral pattern was traceable.

(d) Examination of Yarn Breaks.

The utilisation of the test for the examination of yarn breaks has already been described.[4] On examining the yarn by the Congo Red test it is possible to determine the number of fibres present at the point of breakage and the average number of fibres ending naturally in the portion of yarn in which the break occurs, so that the number of fibres that have been broken may be found. The average number of fibres in the cross section of the yarn can be determined by counting those at a cut end, and so the percentage of broken fibres may be calculated.

(e) Determination of the Amount of Bleached Stock in a Yarn.

The degree of bleaching or over-bleaching of a fabric is usually determined by fluidity measurements, but the Congo Red test has been found useful in the examination of yarn for the presence of bleached stock, and for the examination of very small samples for evidence of bleaching.

The practice of including a certain proportion of cotton that has been well bleached in the loose state, in order to whiten a yarn, is very common in the knitted undergarment trade; and the Congo Red test has been used to determine the amount of bleached stock in such yarns.

Plate IX, 30, is a photograph of the bleached and normal fibres after swelling in 11 per cent. caustic soda and staining with Congo Red. These fibres were taken from a yarn spun from a mixture of the two, and a fairly accurate estimate can be made of the proportions in which they exist in the yarn.

The following examples give the results obtained from determinations of the amount of fully bleached stock in known mixings (the observers making the determinations in ignorance of the amounts).

(1) Cop containing 50 per cent. bleached stock:—

Bleached	Normal
54·5	45·5

(2) Yarn spun from mixture of bleached and unbleached stock, 50 per cent. of each:—

	Bleached	Normal
Observer A	50·5	49·5
,, B	49·5	50·5

(3) Mixing of 44 per cent. bleached and 56 per cent. normal cotton used:—

	Bleached	Normal
Three separate determinations ...	56	44
	45	55
	49	51

As an illustration of the reproducibility of the test, three observers obtained the following figures in the analysis of the yarn from a knitted garment, in which the relative quantity of bleached and normal fibres was unknown.

	Bleached	Normal
Observer A	21·5	78·5
,, B	18·5	81·5
,, C	25·5	74·5

As has already been said, these results are for fully bleached stock; if the material does not contain fully bleached stock but is suspected, say on account of its colour, to have had some treatment, an ash content determination will decide whether any wet treatment has been given and the Congo Red test may then be used to give some indication of its severity. The effect of mild processing shows only after a preliminary swelling with 18 per cent. caustic soda solution, but 11 per cent. solution is sufficient to show a cuticle effect after an average bleach.

(f) Examination of the Wear of Finished Goods.

The Congo Red test has been applied to the examination of the wear of used fabrics. Such cotton garments as shirts, overalls, knitted underwear, etc., and in addition cotton linings, have all been examined and the effects on the single fibres observed.

Shirts made of satin striped poplin often show a rubbing up and in some places a complete disappearance of the stripes when the rest of the garment gives very little evidence of wear. Examination of the rubbed parts of the stripes after Congo Red staining shows only a disturbance in the arrangement of the fibres in the yarn and there is no indication of abrasion of the individual fibres. This type of wear is characteristic of fabrics woven or knitted from soft yarns where there are long floats or the fabric structure is fairly open as, for example, cellular fabrics, hosiery, etc.

In a poplin weave the fibres are too strongly held to be pulled apart by friction, but the fabric is destroyed by abrasive wear. A poplin cloth is woven with about twice as many ends as picks, and examination under the microscope of a worn poplin gives evidence of damage and breakdown of the crowns of the warp yarns which predominate on both faces of the fabrics. On applying the Congo Red tests to the affected warp the various stages in the breakdown of the fibres may be observed. The portions of fibres on the top of sharp crowns are affected and these show first a loosening of the fibrillar structure (Plate XI, 37, 38) followed by a gradual disruption of the fibres which results in a brush-like appearance of the fibre ends (XI, 39). When the garment has had a considerable amount of laundering and the fibres show some evidence of chemical degradation the fibrillar structure is not so evident; the damaged portions stain red and the broken fibre ends often appear pointed, suggesting that the outer fibrillae have disintegrated and disappeared (XI, 40).

Effects similar to this are found in worn portions of sateen linings, and this is obviously the type of wear to be expected from the very gentle rubbing of the cloth either against the skin or against other cloth.

Overalls are usually made of drill, in which the balance between warp and weft varies considerably; the proportion of weft may be as low as 25 per cent. in a poor quality drill and as high as 66 per cent. in a good quality. An examination of a large quantity of overalls, most of which were of the cheaper quality, showed a decided tendency for breakdown of the weft to occur before any wear on the warp was obvious, and the ends of the broken picks on staining with Congo Red gave evidence of ordinary tension breaks. In the higher quality of drills the first evidence of wear was abrasive damage on the warp—the larger proportion of weft had made it possible for the yarns to stand up to the strains imposed upon them.

Certain types of collars made from double cloth of poplin weave when starched often show a cracking along the fold. Examination under the microscope of the fold after Congo Red staining of the yarn ends reveals this breakdown to be due to shearing of the weft yarn while the warp face yarn shows little or no abrasion. The fibre ends of this type of weft break, depicted in XI, 43, show cross markings and splitting along these markings, the characteristic appearance of fibres that have suffered continual bending strains. This rupture of the weft was found to be the result of pressing a sharp fold into a collar that has been rendered brittle by starching, and the weft, which has little crimp, has cracked under the strain.

Examination of fibres from the worn portions of used garments is of considerable value both in the designing of cloth structures for specific uses and in the devising of machines for the testing of fabrics to predict their behaviour during use. If Plate XI, Figs. 37-40, showing the effect of normal wear on the fibres of a poplin shirt, are compared with Figs. 41 and 42, which show the effect of a carborundum roller on such fibres, it will be obvious that rubbing with a roller of this type is a quite different destructive action from that encountered in normal wear.

VI. SPECIFIC EXAMPLES OF APPLICATIONS OF THE TEST TO THE EXAMINATION OF DEFECTS IN COTTON GOODS.

The Congo Red test is employed extensively in the examination of defects in cotton goods and is particularly useful when the damage is highly localised, since reliable evidence can be obtained from examination of only a few fibres or parts of fibres, an amount of material which would be inadequate for most other tests. From an examination of a very small quantity of material it is possible to identify:—

(*a*) Normal breaks.
(*b*) Ends clean cut with a sharp instrument.
(*c*) Ends broken by some type of mechanical injury, plucking, rubbing, bruising, etc.
(*d*) Singed fibre ends.
(*e*) Ends damaged by intense chemical attack.
(*f*) Ends tendered by mildew or bacteria.

Usually these different types of fibre ends can be identified easily, but occasional difficulties arise. For example, in a yarn damaged by strong acid the fibre ends are bright red and usually show transverse cracking, but when the acid has been very concentrated the affected portion may be so intensely tendered that any subsequent treatment, however mild, causes the disintegration and disappearance of the damaged portion. A somewhat similar difficulty may arise in the examination for singed ends in a cloth which has been bleached after the singeing, for the tip may be removed by the processing; the appearance is, however, still distinctive and easily recognised by an experienced observer, for the fibres commonly show a transition from solid bright red through fine and coarse spirals to normal, and it is always an easy matter to find in the cloth many examples of fibres that are certainly singed, and these can be used as controls. The cut fibre ends from cloths which have been severely processed or have had repeated launderings do not show the characteristic mushroom shape. The cuticle becomes extensible, the secondary cellulose is not constricted and although the ends are square, indicative of cutting, the cellulose is not protruding. Sufficient evidence can often be obtained from this test alone to explain the origin of defects in materials submitted for examination, but usually the test, though providing essential evidence, must be supplemented by other observations. No particular instructions can be given concerning its employment in cases of this type, but a few instances may be given in which its logical position is apparent.

Case 1. A bleached 3 and 1 twill contained holes due to warp breakage at places where for a short distance a length of weft was missing or folded back on itself, and it was thought that the warp breakage was due to excessive pressure during finishing, causing breakage on the lumps which admittedly were defects but not such as to make warp breakage inevitable. The Congo Red test showed immediately that at the broken warp thread ends many fibres were fired and consequently that the breakage occurred not later than firing. On the weft yarn the test showed firing and mechanical damage intermediate between cutting and bruising, a form of damage which results from the use of cloth nippers. Warp damage in some instances was confined to every fourth end and the facts as a whole indicated that the hole was due to plucking out of loops and snarls from the grey cloth. In this instance the Congo Red test provided most of the necessary evidence but the observations of the missing length of yarn and rupture of every fourth end were necessary to complete it.

Case 2. A dyed mercerised limbric contained holes, and on examination under the microscope the fibre ends at the edges of the hole were found to be more deeply dyed than the rest, showing that the holes were made not later than dyeing. These fibre ends were also much more swollen and more deconvoluted than the normal fibre ends and the holes must therefore have been made not later than mercerising. The Congo Red test showed that the fibres were clean cut and that the proportion of singed fibres was about the same as for the rest of the cloth. The holes were therefore produced by sharp cutting, later than singeing but not later than mercerising. Measurements on the cloth showed that the holes recurred at a fairly regular distance from the selvedge and at a very constant distance of a little over 60 inches along the cloth. The holes were of similar shape and the evidence indicated that they were due to cutting by a projection from a roller of about 60 inches circumference between singeing and mercerisation. Again the examination under the microscope by the Congo Red technique located the stage at which damage occurred, and the distribution of the holes and their similarity of shape completed the evidence. Observations of distribution are of the utmost importance in enquiries of this type, and also in investigations concerning many other types of defect.

Case 3. Large numbers of small dark specks on a dyed down-proof sateen spoiled its appearance. They occurred in pairs and were found on close examination to consist of bunches of fibres protruding from the weft yarn, and the degree of injury to these yarns varied from a few damaged fibres to complete rupture of the thread. The loose fibres were more deeply dyed than the normal, and more swollen and deconvoluted, observations showing respectively that the damage occurred not later than dyeing and not later than mercerisation. The Congo Red test showed an abnormal number of singed fibre ends in the bunches and also that many of the damaged fibres were clean cut. The co-existence of mechanical damage and singeing is important, for though the singeing damage proves that the damage took place not later than singeing, the presence of mechanical damage makes it almost certain that the damage was present on the cloth *before* singeing, for the opportunities of mechanical damage during the actual singeing process are extremely limited compared with the opportunities before singeing, i.e., while the cloth is in the loom, the warehouse, and in transit. The Congo Red test indicated, therefore, that the damage was due to cutting in the loom-state cloth.

Further examination of the cloth under the microscope showed that all the damaged places had one feature in common, namely, that the damage had occurred to the weft thread on the back of the cloth at the point where it crossed the warp. In addition, slight damage to the warp was also found on the back of the cloth, so that although the specks appeared on the face, the actual damage was on the back. The multitudes of small points of cutting on the back of the cloth before singeing could mean only damage on the sand-roller of the loom.

Case 4. Another down-proof sateen showed a defect identical in general appearance with the last example, the specks were numerous, occurred in pairs, and were due to bunches of weft. In this case, however, there were no partially broken weft threads and the Congo Red test showed that all the fibres in the bunches were singed, and there was no trace of cutting. The specks were therefore produced during singeing and were due to the firing of small loops and snarls of which there were many in the grey cloth.

The instances so far described have concerned defects in cloth, but the method has been frequently used to trace the cause of difficulty experienced in processing, and two examples will be of interest.

Case 5. A batch of yarn spun from a certain mark of cotton gave a much lower strength than was usual in the particular quality spun from this mark, and on examination of the yarn by the Congo Red technique it was found that the fibres were very seriously tendered by mildew. The mildew tendering was later shown to be present in the raw cotton.

Case 6. In another instance yarn dyed on beam and subsequently pirned gave trouble on account of breakage during weaving. Measurements of fluidity showed that the yarn had not been chemically tendered, and the yarn was not obviously weak in single-thread tests. It was realised, however, that the single-thread tests examined only a small amount of material and a long length was therefore run through a continuous tensile tester—an instrument which breaks out all places of strength below a predetermined value—and in this way a large number of very weak places in the yarn were discovered. These, on examination by the Congo Red test, proved to be places where the yarn had been severely tendered by bacteria.

The combination of the continuous tensile test and the Congo Red test has proved a very useful method of investigating difficulties in the processing of yarns, and in this way weak places too infrequent to affect the ordinary thread tests, but sufficiently frequent to be troublesome in practice, have at various times been traced to local attack by bacteria, mildew, chemical agents, and abrasion.

APPENDIX

RELATION BETWEEN THE WALL THICKNESS AND SPIRAL SPLITTING OF THE WALL OF UNTREATED COTTON FIBRES.

In order to determine how far the splitting of the cuticle of fibres from a raw cotton is dependent on the degree of thickening of the fibre, the wall thickness and ribbon width of various cotton fibres at different points along the fibres were drawn and measured, the fibres swollen and stained with Congo Red, and classified as split, normal, thin-walled and dead.[2]

Samples were taken from three cottons.

(*a*) Broach C.6. A short, coarse Indian cotton.

(*b*) Texas mixing consisting of 75 per cent. Texas, 10 per cent. Argentine, and 15 per cent. West African.

(*c*) Sakel.

For the determination of wall thickness and ribbon width, strips of black adhesive paper were fastened across a microscope slide leaving a gap, one centimetre wide, down the middle. The fibres were mounted across this, tension was put on to straighten them, and the ends were fastened down with "Necol" cement. Water was used as a mountant and a cover slip was placed over them. The edge of the adhesive paper provided a starting point for indicating the position of definite fields, and the arrangement ensured that only the middle portion of the fibre was examined, i.e. the portion examined in the immaturity test.[5]

A microscope with a ⅙-inch objective and 10× eyepiece was used, and by means of the Abbe drawing apparatus the ribbon width and wall thickness were indicated as in Fig. 2.

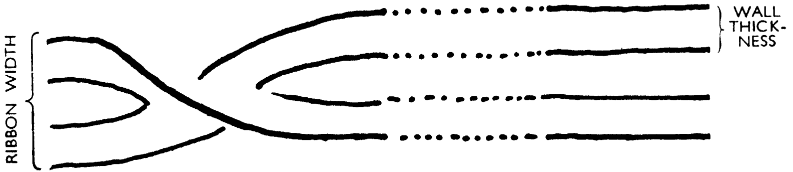

FIG. 2

There are two difficulties inherent in this method. It is necessary to use water as a mounting medium since the fibres are to be swollen with caustic soda later, and the definition of the edge of the fibre is not as sharp as could be obtained with a mounting medium such as paraffin. Again, the fibres being convoluted ribbons have a tendency to roll, so that the measured ribbon width is less than the true ribbon width. This limitation applies chiefly to the thin-walled and normal fibres rather than to the thick-walled, and is a systematic error giving a low value for the ribbon width. Occasionally the edge of the fibre rolls over, making it difficult to distinguish between the rolled edge and the wall. In view of these difficulties it was decided to make projections of the ribbon width and wall thickness only at those fields where the fibre was obviously not rolled over, and where the wall thickness could be drawn with no very obvious error; they were therefore made at the middle of the convolution where the ribbon width is at its maximum.

Several fibres were mounted on a slide as described, and the ribbon width and wall thickness of certain fields were drawn, five or six fields being examined on each fibre. Measurements were made individually on each field, and the positions of these fields carefully noted. The fibres were then swollen with 18 per cent. caustic soda solution followed by Congo Red staining, after which the same fields were re-examined and classified as split, normal, thin-walled and dead. Where there was obvious mechanical damage the fibre was ignored. The number of fields was 88 for the Broach, 135 for the Texas, and 100 for the Sakel, making a total of 322.

The wall-thickness/ribbon width ratio was calculated for each field, with the results given in Table VIII.

Table VIII

	Split	Normal	Thin-walled	Dead
	Ratios, wall thickness/ribbon width.			
Broach	0·42	0·33	0·21	—
Texas	0·37	0·27	0·20	0·05
Sakel	0·38	0·25	0·18	—
Mean	0·39	0·29	0·19	0·05
Standard deviation	0·064	0·069	0·066	—
Standard error	0·006	0·007	0·007	—

Frequency arrays of the individual results are shown in Figs. 3 and 4. The differences between the means of the groups are statistically significant, and show that fibres that split have a greater degree of thickening than fibres that do not.

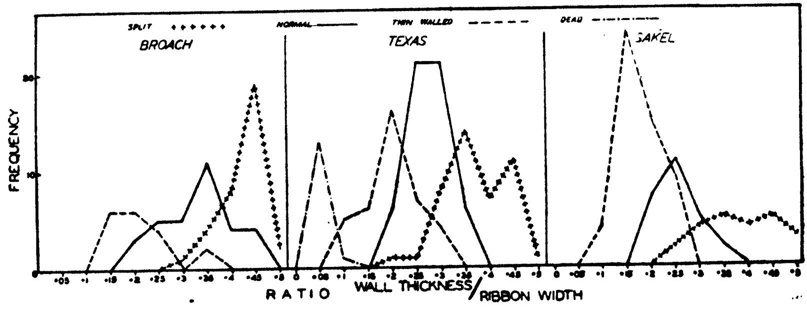

FIG. 3.

Further confirmation has been obtained by determining the fibre-weights of the various classes of fibres in five cotton samples comprising the above Texas mixing, a Broach, two Sakel samples, and an Ecuador.

A staple diagram was made and divided into five equal portions by number after discarding fibres less than 15 mm. long. From each portion approximately equal numbers were taken, centimetre lengths cut, stained with Congo Red after a preliminary swelling in 18 per cent. caustic soda, then classified as split, normal, thin-walled, and dead. The fibres from each group were placed separately in a glass vessel containing water and thoroughly washed by stirring with compressed air. After repeating with several changes of water, the fibres were dried, counted again, and weighed. The values obtained are recorded in Table IX.

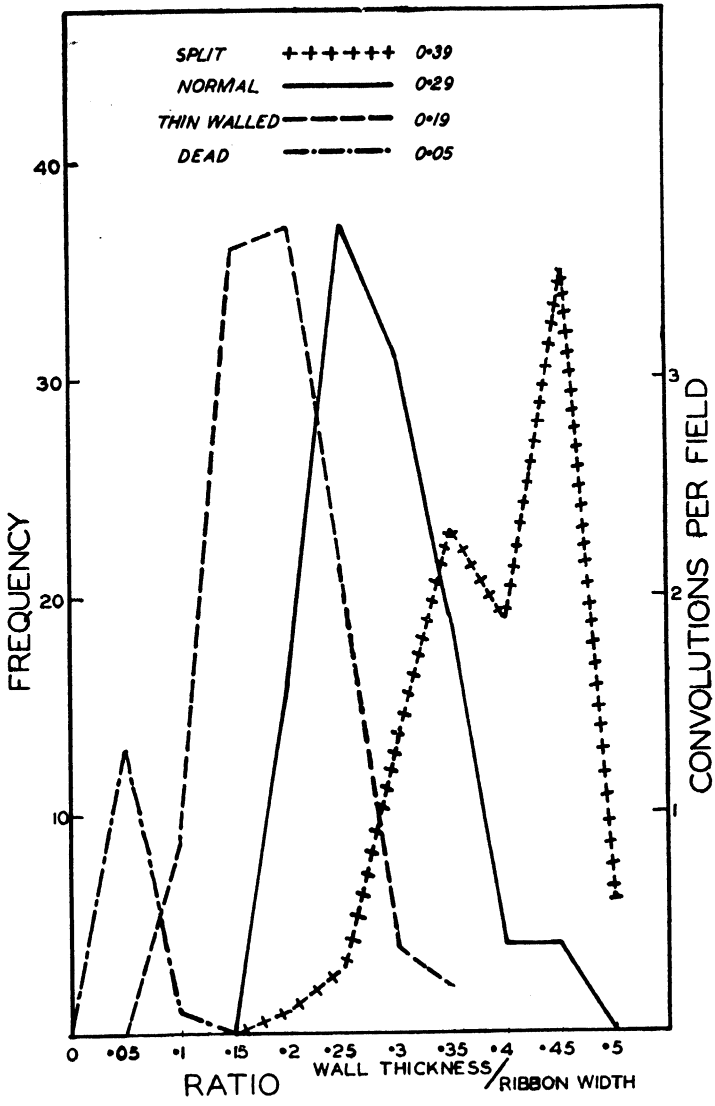

FIG. 4

Table IX

Cotton	Split	Normal
Mixture of Texas and Argentine and West African ...	279	263
C/6 Broach	359	320
C/64 Sakel Sample (*a*)	187	167
C/64 Sakel Sample (*b*)	185	161
C/36 Ecuador	340	298

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[4] Clegg. *Shirley Inst. Mem.*, 1926, 5, 223 ; or *Journ. Text. Inst.*, 1926, 17, T.591.

[5] Clegg. *Shirley Inst. Mem.*, 1932, 11, 1-20 ; or *Journ. Text. Inst.*, 1932, 23, T.35-54.

[6] Clibbens and Ridge. *Shirley Inst. Mem.*, 1928, 7, 85 ; or *Journ. Text. Inst.*, 1928, 6, T.389.

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LIST OF ILLUSTRATIONS OF FIBRES AFTER CONGO RED STAINING

Readers are reminded of the statement on p. 53 that "photographs scarcely do justice to the preparations as seen under the microscope."

PLATE I. (1) Mechanically damaged fibre.
(2), (3) Spiral splitting of cuticle of abnormally thickened fibres—slow or cuticle spiral.
(4) Spiral splitting of cuticle of abnormally thickened fibres—showing torn cuticle.

PLATE II. (5), (6), (7), (8), (9). Progressive stages of heat tendering.

PLATE III. (10, (11), (12), (13). Spiral splitting of cuticle of bleached and over-bleached fibres.

PLATE IV. Fibres showing quick spirals.
(14) Bleached fibre.
(15) Fibre from yarn tendered by fungus.
(16) Fibre from warp satin after schreinering at 71°C.
(17) Fibre from warp satin after schreinering at 170°C.

PLATE V. Ends of single fibres.
(18) Broken in single thread tester.
(19) Broken by rubbing with file—abrasion.
(20) Local chemical tendering.
(21) Cut ends of fibres.
(22) Singed ends of fibres.

PLATE VI. (23), (24). Fibres from light tendered cotton (loss of strength 52%).

PLATE VII. (25) Fungus tendered fibre.
(26) Fibre tendered by bacteria.
(27) Fibres from boll attacked by *Aspergillus niger*—attacked fibres have no secondary thickening and stain bright red. Unattacked fibres have secondary thickening and do not stain.

PLATE VIII. (28) Fibres from mercerised hanks showing acid tendering.
(29) Fibre from acid-tendered sliver (treated for 40 hours with hydrochloric acid 200 g/l) showing beginning of transverse cracking.

PLATE IX. (30) Mixture of grey and bleached fibres taken from yarn.
(31) Fibres from cloth showing abrasion due to rope marking.

PLATE X. (32) Tip of fibre.
(33) Base.
(34) Abnormality showing crack
(35) Bruised fibre.
(36) Fibre showing damaged secondary cellulose " torn."

PLATE XI. (37), (38), (39) Fibres from warp of poplin subjected to abrasive wear showing loosening and breakdown of fibrillar structure.
(40) Fibre from warp of well-laundered poplin abraided to rupture.
(41), (42) Fibre from poplin subjected to wear test by a carborundum roller.
(43) Fibres from cracked weft of poplin showing square fibre ends and cross markings, some of which show splitting.

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PLATE III

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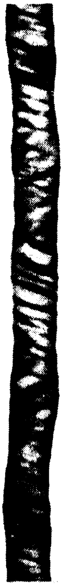

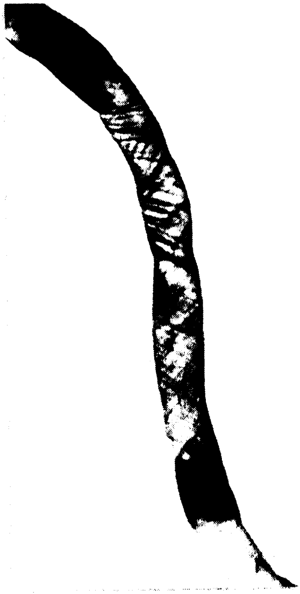

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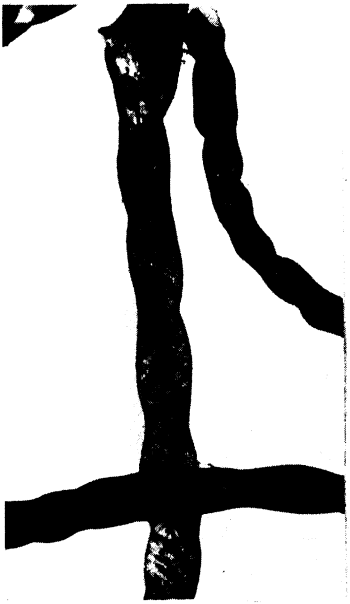

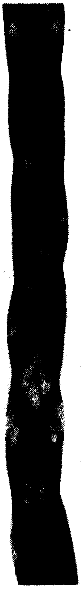

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PLATE IV

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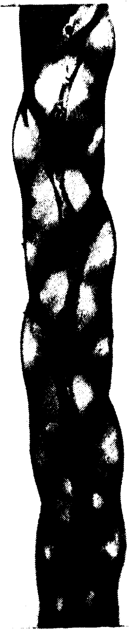

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PLATE V

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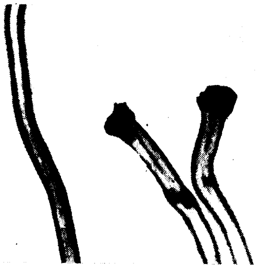

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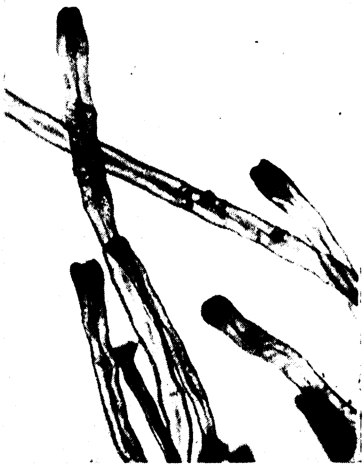

PLATE VI

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PLATE VII

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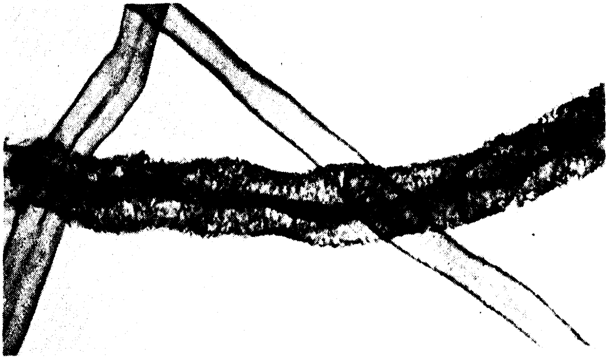
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PLATE VIII

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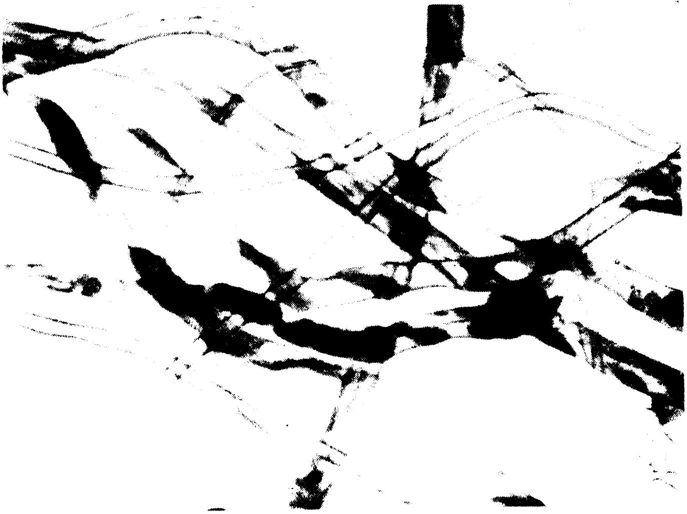

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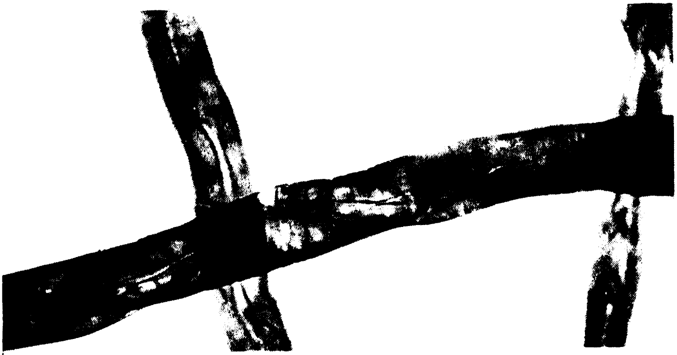

PLATE IX

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PLATE X

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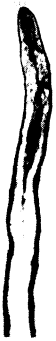

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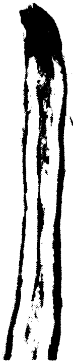

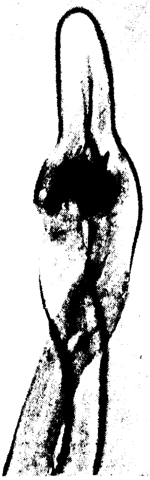

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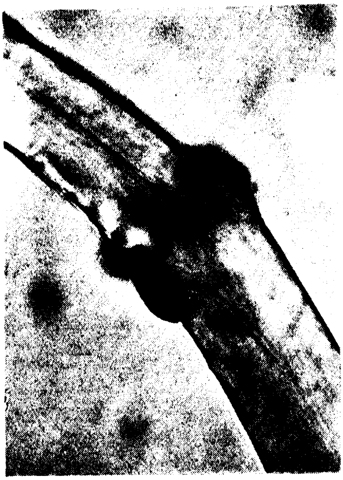

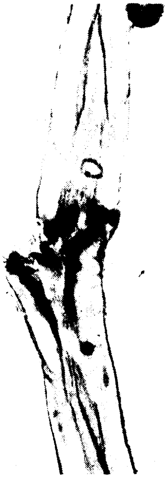

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PLATE XI

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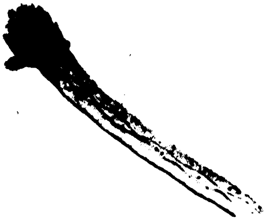

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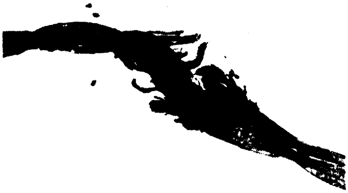

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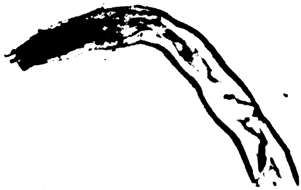

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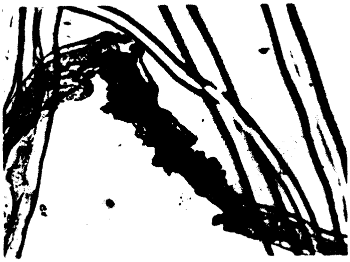

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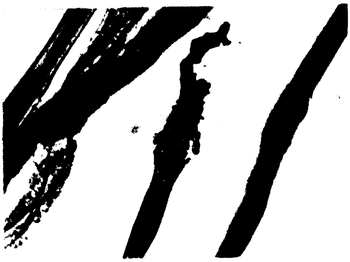

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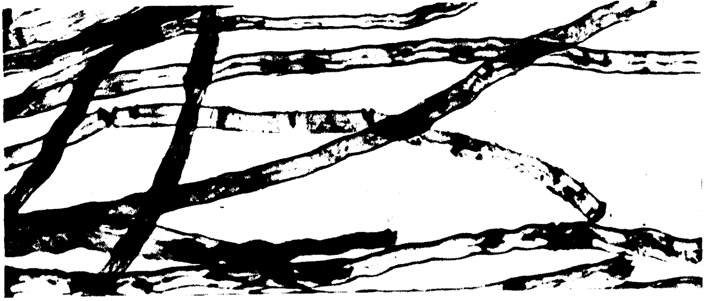

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TRANSACTIONS

6—THE DENSITY AND SWELLING OF SILK FILAMENTS IN RELATION TO MOISTURE CONTENT

By A. C. GOODINGS and L. H. TURL

(Ontario Research Foundation, Canada).

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INTRODUCTION

The values of the density of silk that have been recorded in the scientific literature differ widely among themselves and are given without precise definition of the condition of the material. No recent work appears to have been done in this field, the scant data which are available being summarised by Denham and Lonsdale(1) from the investigations between 1890 and 1907 of a group of French observers at Lyon. These values range from 0·887 to 1·45 g. per c.c. No mention is made of the variations in density which arise from the absorption of moisture and accompanying swelling.

In the investigation of certain physical properties of the silk filament, the area of cross-section must be known. To arrive at a mean area of cross-section for a filament it will be shown in a subsequent paper that direct weighing, coupled with a knowledge of density and length, possesses considerable merit. For this specific reason as well as for the associated general interest, a study of the variation of the density of silk with regain was undertaken.

A knowledge of the regain-relative humidity relationship for silk is essential to the interpretation of experimental results obtained with the material exposed to different conditions of relative humidity. Since it may be anticipated that moisture absorption properties differ slightly for different types of silk, it was advisable to determine the precise relation between regain and relative humidity for the silk to be used in subsequent investigations. Further, no complete data on the regain of silk defining the boundary curves of adsorption and desorption conditions appear to have been published. For these reasons a more extensive study of the regain of silk than would otherwise have been considered necessary was carried out and is here described in detail.

Intimately associated with the changes in density of silk occasioned by varying moisture content is the swelling of the filament. The present study was extended to include the evaluation of linear dimensional swellings as well as the volume swelling given by density data. For reasons of clarity of presentation as well as for the separate interest associated with the results of each section of the investigation, the material to be discussed is presented under the headings: (1) the regain of silk, (2) the density of silk, (3) the swelling of silk.

1. THE REGAIN OF SILK

The regain of silk and its dependence upon relative humidity appear to have been first investigated by Schloesing[2] whose studies were extended to show the effect of temperature upon moisture absorption, and included silks of various sources. At that time, however, the fact was not recognised that the regain of silk, and other textile fibres, in equilibrium with any given set of conditions of relative humidity and temperature depends on the manner in which equilibrium is reached. Silk approaching equilibrium with a given atmosphere will attain a minimum, maximum, or intermediate value of regain dependent upon its previous moisture condition. Minimum and maximum boundary regain curves define the upper and lower limits of the moisture content of silk that can exist in equilibrium with an atmosphere of any particular relative humidity and temperature, and may be unequivocally determined with silk initially absolutely dry and saturated with moisture, respectively. These boundary curves are commonly referred to as the adsorption and desorption regain curves of the material.

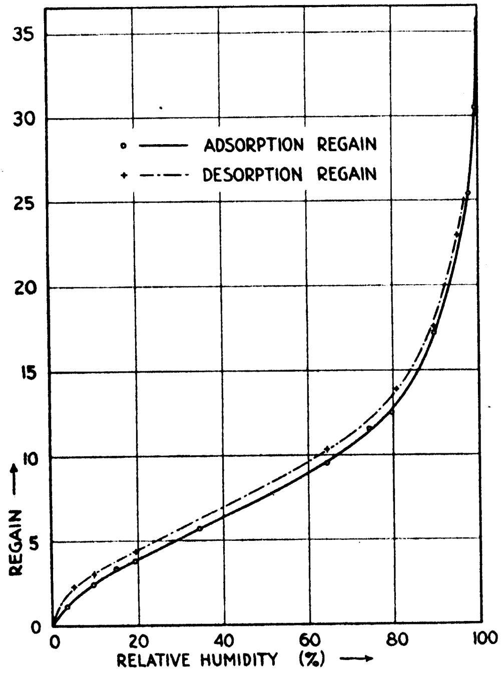

Fig. 1

A brief note by Denham and Allen(3) gives some data on desorption regain for three types of mulberry silk and one sample of tussah silk. Practically identical values for the three former silks are recorded, with higher values for tussah at corresponding relative humidities. In a paper by Oguri(4), the regain-relative humidity relationship of silk is given attention but without reference to the hysteresis factor involved. The present study was made to provide complete data concerning the adsorption and desorption boundary regain curves at 25° C. for the silk to be later used in investigations on density, swelling, and other properties.

Experimental

A small skein of 13/15-denier high grade Japanese white silk was degummed and purified according to the following procedure:—Immersed for 1 hour in 1% soap solution at 98° C., rinsed in hot distilled water, immersed for 1 hour in 0·5% soap solution at 98° C., rinsed thoroughly in hot distilled water, treated for 15 minutes in 0·6% hydrochloric acid solution, rinsed thoroughly, treated for 15 minutes in 0·6% ammonia solution, rinsed thoroughly, extracted in a Soxhlet successively with alcohol, ether, and again with alcohol, rinsed thoroughly in water, allowed to soak in water at 50° C. for 1 hour, and finally dried in air at room temperatures. The sericin, natural salts, and waxes are removed by this treatment and the filaments of fibroin left in a high degree of purity.

The air-dry skein was cut into a number of samples, each in the form of a sheaf bound loosely about the middle with a silk thread and weighing between 0·3 and 0·4 g. These samples were kept in weighing bottles over phosphorus pentoxide until perfectly dry as determined by a constancy in weight. The regain measurements were made using an accurately calibrated quartz spiral of some 20 turns having a sensitivity of 83·6 mm. per g. A sample of the silk was suspended from the spiral by means of a short length of fine platinum wire and enclosed in a special glass chamber fitted with an inside trough into which a solution of sulphuric acid could be run from an attached reservoir to establish a known relative humidity within the chamber (data according to R. E. Wilson(5)). The whole assembly was placed in an air-thermostat and kept at 25° C. controlled to within three one-hundredths of a degree. After temperature equilibrium had been reached, the sulphuric acid solution was run into the trough from the reservoir and the chamber quickly exhausted to a pressure between 10 and 20 mm. of mercury to facilitate diffusion. The acid concentration was found to show no measurable change as a result of this evacuation. The length of the quartz spiral was measured through a plane glass window with a cathetometer, and equilibrium regain was indicated by constant length of the spiral. In the case of desorption regain measurements, the sample was suspended over water in a closed vessel for several hours prior to exposure to the controlled atmosphere in the test chamber. This precaution of approximating a saturated condition in the silk was observed in all desorption regain determinations although probably unnecessary in the case of low values where the change in moisture content from initial to equilibrium condition was large. That the silk contained the high regain desired prior to the determination of a desorption value was checked by observations of its weight.

The results obtained are given in Table I and shown graphically in Fig. 1.

Table I

Relative Humidity (%)	Regain at 25° C.	
	Absorption	Desorption
3·5	1·1	—
5·1	—	2·3
9·9	2·4	3·0
15·1	3·4	—
19·5	3·8	4·3
34·5	5·7	—
64·5	9·5	10·3
74·5	11·6	—
79·9	12·5	—
81·0	—	13·9
89·8	17·2	17·5
95·4	—	23·9
97·5	25·4	—
99·4	30·5	—

The value of 35·8% for the regain of silk at saturation shown in Fig. 1 has been deduced from density and swelling data and will be discussed in a later portion of the paper.

2. THE DENSITY OF SILK

The problem of the measurement of the volume of textile fibres has been approached in various ways. In his work on wool, King(6) determined the specific gravity of the fibre by weighing in air and in benzene, using a specific gravity bottle method, some form of which has been adopted in most published work. The high surface tension of mercury renders that liquid incapable of complete contact with the boundaries of the fibre and hence unsuitable for the purpose of measurement of fibre volume. This fact is borne out by the value of 0·887 g. per c.c. obtained for silk by Vignon using mercury. In addition to this requirement of complete contact between liquid and fibre, the measurement of volume of fibre by displacement in a liquid requires that the liquid does not penetrate the interior of the fibre. In the case of a liquid such as water which is capable of penetration and for which the fibre possesses an affinity, a swelling of the fibre accompanies the absorption. Whether such an affinity exists between liquid and fibre, assuming that penetration is possible, can be tested in several ways. In the case of wool, King showed that benzene is not appreciably absorbed when wool is exposed to benzene vapour and that there is no observable swelling of the fibre in the water-free liquid. He showed further that the values of density for the dry fibre obtained using benzene, nitrobenzene, or olive oil as the immersion medium were practically identical. This identity of results with liquids so widely different in molecular size as benzene and oleic acid would point to the conclusion that no penetration had occurred with any of the liquids, a conclusion later substantiated by Speakman(7) in his studies of the structure of the wool fibre. As a result of his observations, King concluded that the density as measured by displacement in these liquids is the true density of wool. In his work on the specific volume of cotton cellulose, Davidson(8) measured volume by displacement of helium and also toluene. His results showed the helium value to be about 1% lower than the toluene value, indicating that toluene could not penetrate the fibre at least to the same extent as the gas.

On grounds of certain broad similarities of structure between wool and silk, it is probable that benzene is unable to penetrate the dry silk filament. It is conceivable, however, even in the case of a liquid inert towards silk, that where entry into the dry filament may be prevented by virtue of the size of the molecules composing the liquid, the swelling of the fibre accompanying moisture absorption may permit entry at some higher regain. Where an affinity between fibre and liquid exists, access of that liquid to the interior of the fibre can fairly readily be demonstrated. In the case of a liquid which is relatively inert towards the fibre, however, it is considerably more difficult to decide whether or not penetration occurs when molecular size does not preclude the possibility. That no affinity is evidenced between silk and benzene was shown by exposing dry and conditioned silk to saturated benzene vapour and, in agreement with the results of King on wool, no measurable increase in weight of silk occurred.

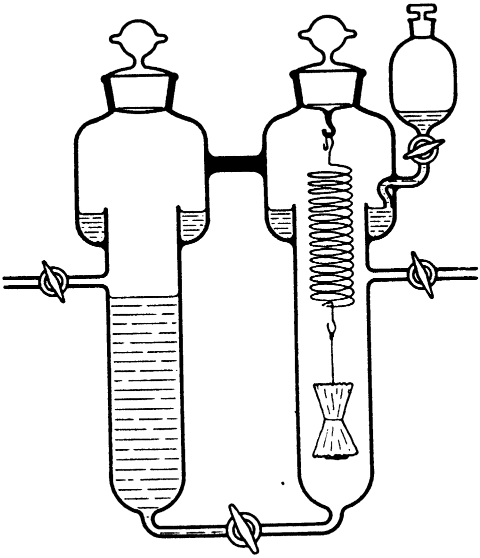

Fig. 2

Based upon these considerations, the method adopted in the present investigation of density was one of immersion in benzene. Indirect proof that the density values of silk obtained from volume measurements determined by displacement in benzene are reasonably accurate is afforded by the fact that the swelling of silk derived from such density data shows excellent agreement with values for swelling measured by a direct and completely unrelated method. This agreement is reported in more detail in connection with swelling.

Experimental

The apparatus used in the determination of density was an augmented form of that employed for the regain investigation and is shown diagrammatically in Fig. 2. To the chamber containing the silk sample a second chamber was connected through a valve opening into the bottom of each chamber. Benzene, carefully purified and freed from moisture, was placed in the second chamber in contact with a partially evacuated atmosphere controlled at the same relative humidity as in the silk chamber. This conditioning of the benzene was designed to avoid error due to interchange of moisture between silk and benzene on immersion, and that no significant interchange did occur is borne out by the fact that the apparent weight of the silk in the benzene did not show any progressive change during the time of immersion involved. The temperature was thermostatically controlled at 25° C. as in the regain determinations.

The silk sample was allowed to reach equilibrium regain under a pressure of 20 mm. or less of mercury, and the benzene then admitted through the communicating valve. The evacuated state of the silk served to reduce errors due to the occurrence of air bubbles in the sample. It was found comparatively easy to eliminate difficulties due to air dissolved in the benzene by manipulating the pressure above the benzene in the silk chamber. While the reduction of pressure enabled any bubbles trapped in the silk to expand and escape, the subsequent restoration of atmospheric pressure served as a further safety measure in reducing any remaining bubbles to negligible dimensions or forcing them into solution. The apparent weight of the silk was then observed and the absence of bubbles proven by repeating the observation at a very much reduced pressure. In every case reported no difference was observed in the apparent weight at the two pressures. A small correction was made for the apparent weight of the platinum wire suspending the sample. Effects due to the surface tension of the benzene upon the wire were found to be of the order of the experimental error and could be neglected. Determination of the density of the benzene at 25° C. gave a value of 0·8713 ± 0·0002 g. per c.c. The results of the density determinations on silk at different values of regain are given in Table II and shown graphically in Fig. 3.

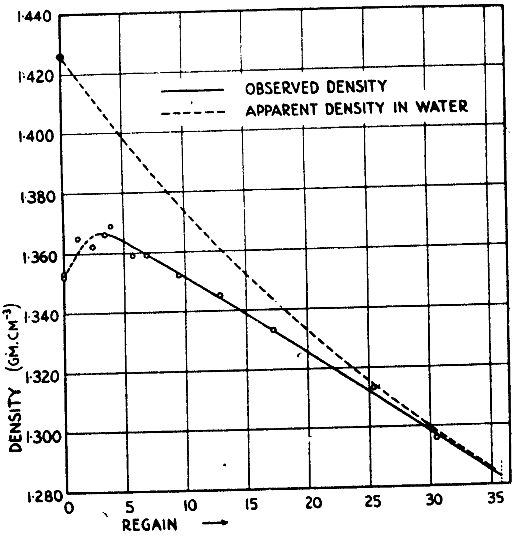

Fig. 3

Table II

Regain	Weight in air (g.)	Apparent weight in Benzene (g.)	Density (g. per c.c. at 25° C.)
0	0·3247	0·1156	1·353
0	0·3631	0·1290	1·352
1·1	0·3215	0·1161	1·365
2·4	0·3947	0·1422	1·362
3·4	0·4055	0·1469	1·366
3·8	0·3238	0·1178	1·369
5·7	0·3580	0·1285	1·359
6·8	0·3657	0·1312	1·359
9·5	0·3185	0·1131	1·352
12·8	0·3775	0·1329	1·345
17·2	0·3759	0·1308	1·333
25·4	0·4500	0·1514	1·313
30·5	0·4480	0·1468	1·296

Some scattering of the experimental values of density at low regain is to be observed but an initial rise is definitely indicated. A smooth curve drawn through the experimental points shows a rise to a maximum density at a regain in the neighbourhood of 3·5% followed by a gradual decrease at higher moisture content. From a study of this and other properties of silk, there is evidence for the belief that some differentiation may be made between the first few per cent. of regain and that which is subsequently taken up under conditions of suitably high relative humidity. In connection with the possible penetration of silk by a liquid which does not itself cause swelling, it will be seen in the discussion of volume swelling that the maximum volume which could be available within the filament for the reception of such a liquid diminishes rapidly in the early stages of moisture absorption.

Apparent Density in Water

In the determination of density, if volume measurement is attempted by displacement in a liquid which is absorbed by silk, an apparent density value is obtained. In connection with the absorption of water and attendant swelling of silk the apparent density which would be obtained using water as the immersion medium is of interest. This is given by the relation

$$D' = D_w \frac{100+R}{\frac{D_w}{D}(100+R_s) - R_s + R}$$

where D' is apparent density, D_w and D_s the density of water and saturated silk, respectively, R the regain of the silk and R_s its regain at saturation.

If the apparent density of silk at zero regain is written D'_0, the above expression can be rewritten:—

$$D' = \frac{100+R}{\frac{100}{D'_0}+\frac{R}{D_w}}$$

so that if the apparent density for dry silk is known, the apparent density for all other values of R can be calculated. By direct weighing in air and in water, suitable precautions being observed in the removal of all air bubbles from the silk in the latter case, it was found that at 25° C.

$$D'_0 = 1{\cdot}426 \text{ g. per c.c.}$$

$$\text{whence } D' = \frac{100+R}{70{\cdot}1+1{\cdot}003R} \text{ g. per c.c.}$$

In Fig. 3 the apparent density curve calculated from the above formula is compared with the true density-regain curve. Assuming the identity of the condition of silk at 100% relative humidity and in water, the point of coincidence of the two curves must be the saturation regain of silk. It is not possible, however, to arrive at a value for saturation regain in this way due to the acute approach of the true and apparent densities near saturation, thereby necessitating definition of the true density curve with an accuracy which extrapolation of the experimental results does not permit.

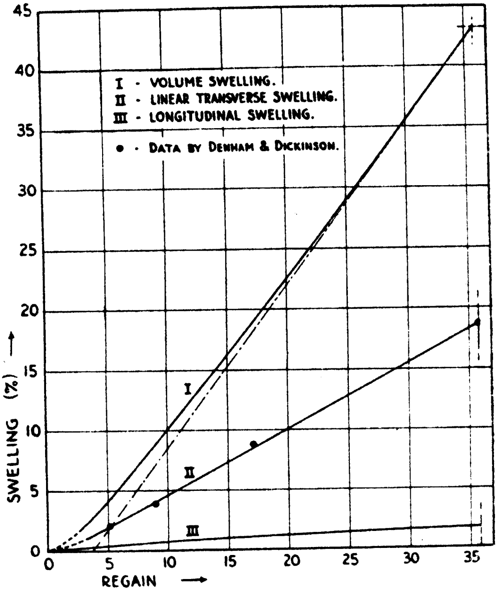

Fig. 4

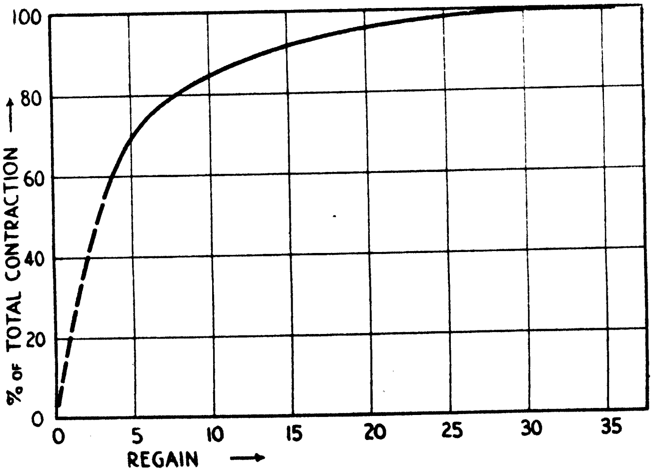

Fig. 5

3. THE SWELLING OF SILK

(*a*) *Volume Swelling.* The volume swelling of the silk filament which accompanies absorption of moisture can readily be calculated from density data and is shown graphically in Fig. 4.

$$\text{Per cent. Volume Swelling } S_V = \frac{V_R - V_0}{V_0} \times 100 = \frac{D_0(100+R)}{D_R} - 100$$

Although marked volume swelling with absorption of moisture is exhibited by the fibre, a contraction takes place in the total volume of dry silk plus absorbed moisture, as is evident from the fact that the apparent density in water is consistently greater than the true density for all values of regain. Further, approximately 70%* of the total contraction observed for saturated silk occurs during the absorption of the first 5% of regain, as shown in Fig. 5. It will also be observed from Fig. 4 that beyond this region the absorption of moisture is accompanied by volume swelling which approximates to the actual volume of the water taken up. This approximation becomes closer as higher regain values are reached, a fact illustrated in Fig. 4, by the approach of the volume swelling curve to the broken line which has been drawn parallel to a line relating the normal volume of water to its mass. The difference at saturation between the volume of water absorbed and the increase in the volume of the fibre is equivalent to a mass of water approximately 3·7% of the mass of the dry fibre.

(*b*) *Longitudinal Swelling.* The longitudinal swelling of a silk filament is of interest both in itself and because, together with a knowledge of volume swelling, it can be used to deduce cross-sectional swelling. A direct method of measurement was adopted, taking advantage of a limited range of true elasticity and eliminating the effect of the irregular form of the filament.

Experimental

The chief difficulty in determining the length changes in a silk filament occasioned by changes in regain is in the measurement of the true length. Under very small or no tension, this length is indeterminate due to a number of wavy irregularities along the filament. A load of the order of 100 mg. is required to straighten out the wavy form of an absolutely dry filament; the load necessary for this purpose becomes very much less for silk at high regain.

It has been found experimentally, however, that for loads not exceeding 250 mg., the silk filament behaves perfectly elastically even when wet, although for higher loads, depending on the condition of the silk, a permanent deformation is introduced. A series of experiments was therefore carried out on silk filaments at different relative humidities ranging from 0 to 100% in which the extension-load relationship was observed for loads within the limit required for true elastic behaviour. For the application of load a chainomatic device was employed which permitted non-disturbance of the humidity conditions within the test chamber. Due to the great difficulty of maintaining a saturated atmosphere for tests at 100% R.H., these were conducted with the filaments immersed in water.

That no permanent deformation has been introduced during the series of experiments was proved by examination of the behaviour of the filaments at the beginning and again at the end of the series. The behaviour and length of the filaments observed at these times were in complete agreement. The load-extension data thus obtained at each of several humidities and in water showed linear relationships for loads greater than a certain minimum dependent upon the regain of the silk. The extrapolation of these straight lines to the axis of zero stress eliminated the effect of the irregularities and indicated the true length of the filament.

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* See Addendum.

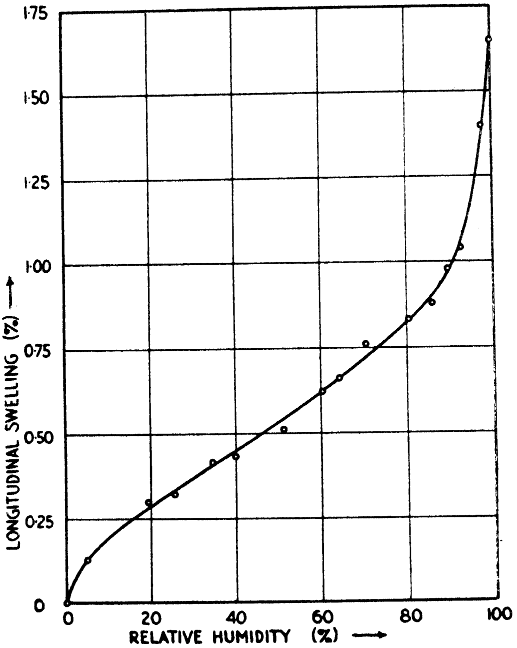

Fig. 6

By way of illustration the following results obtained at 65% R.H. are quoted.

Load (mg.)		Length Observed (cm.)
18	(weight of hook)	9·770
56		9·786
76		9·788
96		9·791
120		9·796
153		9·800
194		9·805
226		9·811
18		9·770
True length at zero load (by extrapolation) =		9·777 cm.

The longitudinal swelling as a percentage of the length of the dry filament is shown in Fig. 6, plotted against relative humidity, and in Fig. 4 plotted against regain. It will be seen that the curve of Fig. 6 is sigmoid in form resembling the regain-humidity relationship. Of significance is the fact that, to a first approximation at least, equal increments of regain produce equal increments of length throughout the entire range of moisture absorption. The value of the longitudinal swelling in water, found to be 1·65% ±0·05, is of particular interest in connection with an estimate of the regain at saturation.

(*c*) *Lateral Swelling*. The cross-sectional swelling of the silk filament with regain can readily be evaluated from the data obtained for the volume swelling and longitudinal swelling. On the assumption that the percentage lateral swelling (linear transverse swelling) measured in a plane perpendicular to the axis of the filament is independent of direction, this lateral swelling can also be calculated. The results so obtained from the data of the present work are shown in Fig. 4. Included in this graph are experimental data on lateral swelling of silk obtained by Denham and Dickinson(9) from direct microscopic measurements. It is to be observed that the two sets of data are in excellent agreement, although the methods employed to obtain them differ entirely.

The Regain and Density of Saturated Silk

Due to the extreme experimental difficulties arising from condensation, a value for the regain of saturated silk was not attempted by direct weighing in an atmosphere of 100% relative humidity. The measurement of the lateral and longitudinal swellings of saturated silk present no such difficulties, however, and from these data the volume swelling of the silk can be calculated. Taking the value of 18·7% found by Denham and Dickinson for the lateral swelling, and 1·65% for the longitudinal swelling, the volume swelling for saturated silk is 43·2%. By extrapolation of the experimental curve relating volume swelling to regain, this volume swelling is found to correspond to a regain of 35·8%. Similarly the density of saturated silk has been deduced to be 1·283 g. per c.c.

SUMMARY

1. The regain of degummed, white Japanese silk has been measured at 25° C. under both adsorption and desorption conditions for relative humidities ranging from dryness to saturation. A value of 35·8% regain for saturated silk has been deduced from density and swelling data.

2. Values for the density of the same degummed Japanese silk at moisture contents ranging from dryness to saturation have been determined.

3. The longitudinal swelling of silk filaments accompanying moisture absorption has been measured.

4. The lateral swelling of silk has been computed from the measured longitudinal swelling and the volume swelling derived from density data.

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March 21*st*, 1940.

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ADDENDUM*

The following examples of the calculation of values represented in the curve of Fig. 5 will assist in an understanding of the derivation of this curve from the data shown in Fig. 3.

For 35·8% regain

$$\left.\begin{array}{l}\text{1 g. of dry silk occupies } \dfrac{1}{1\cdot353} = 0\cdot739 \text{ c.c.} \\ \text{0·358 g. of water occupies 0·359 c.c. (at 25° C.)}\end{array}\right\} 1\cdot098 \text{ c.c.}$$

But 1·358 g. of moist silk actually occupy

$$\frac{1\cdot358}{1\cdot283} = 1\cdot059 \text{ c.c.}$$

$$\therefore \text{ contraction } = 0\cdot039 \text{ c.c.}$$

$$\text{and \% contraction } = \frac{0\cdot039}{1\cdot098} \times 100 = 3\cdot55$$

For 5% regain

$$\left.\begin{array}{l}\text{1 g. of dry silk occupies } \dfrac{1}{1\cdot353} = 0\cdot739 \text{ c.c.} \\ \text{0·05 g. of water occupies 0·050 c.c.}\end{array}\right\} 0.789 \text{ c.c.}$$

But 1·05 g. of moist silk actually occupy

$$\frac{1\cdot05}{1\cdot364} = 0\cdot770 \text{ c.c.}$$

$$\therefore \text{ contraction } = 0\cdot019 \text{ c.c.}$$

$$\text{and \% contraction } = \frac{0\cdot019}{0\cdot789} \times 100 = 2\cdot41$$

For 10% regain

$$\left.\begin{array}{l}\text{1 g. of dry silk occupies } \dfrac{1}{1\cdot357} = 0\cdot739 \text{ c.c.} \\ \text{0·10 g. of water occupies 0·10 c.c.}\end{array}\right\} 0\cdot839 \text{ c.c.}$$

But 1·10 g. of moist silk actually occupy

$$\frac{1\cdot10}{1\cdot352} = 0\cdot813 \text{ c.c.}$$

$$\therefore \text{ contraction } = 0\cdot026 \text{ c.c.}$$

$$\text{and \% contraction } = \frac{0\cdot026}{0\cdot839} \times 100 = 3\cdot10$$

$$\text{Thus for 5\% regain, \% of total contraction } = \frac{2\cdot41}{3\cdot55} = 68\%$$

$$\text{and for 10\% regain, \% of total contraction } = \frac{3\cdot10}{3\cdot55} = 87\cdot3\%$$

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[*] Suggested by one of the referees.—*Editor.*

THE JOURNAL OF THE
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TRANSACTIONS

7—THE PROPERTIES OF THE OXYCELLULOSES FORMED IN THE EARLY STAGES OF THE OXIDATION OF COTTON CELLULOSE BY PERIODIC ACID AND METAPERIODATE.

By G. F. DAVIDSON, D.Sc.

(The British Cotton Industry Research Association)

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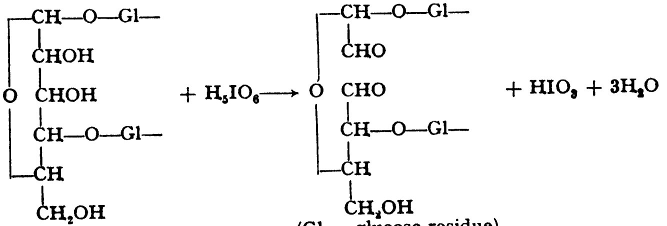
INTRODUCTION

Until recently it was widely assumed that oxidative attack on the cellulose molecule occurred at the primary alcohol group which is present in each glucose unit. The work of Jackson and Hudson[1] has shown, however, that this is not true of oxidation by periodic acid. They showed that the main reaction in the oxidation of cellulose by this oxidant consists in the splitting of the carbon chains in the glucose units between carbon atoms 2 and 3, with conversion of the secondary alcohol groups to aldehyde groups, according to the equation:—



(1)

(Gl = glucose residue)

The inter-relations of the various measurable properties of chemically modified celluloses (hydro- and oxy-celluloses), prepared from cotton by the action of acids and of oxidizing agents under a variety of conditions, have been the subject of extensive investigations in these laboratories, and it therefore seemed desirable to study by the same methods the properties of oxycelluloses obtained by means of periodic acid, the oxidizing agent whose mode of attack on cellulose has been most definitely established.

As a result of the systematic investigation of chemically modified celluloses it has been shown that certain products of predominantly reducing character, obtained by the oxidation of cellulose in acid and neutral media, are characterized by behaviour which suggests that linkages in their chain-molecules are broken by very mild alkaline treatments.[2, 3.] In a preliminary note[3] it has been reported that periodic acid oxycelluloses belong to the extreme reducing type of oxycellulose and exhibit this property of alkali-sensitivity in a high degree. The present paper gives a detailed account of the results on which these conclusions are based, including a description of the properties of products obtained by the oxidation of cotton linters and yarn with periodic acid and potassium metaperiodate and a comparison with typical modified celluloses previously studied. The properties considered are: the copper number; the absorption of Methylene Blue; the fluidity in cuprammonium solution (called the " cellulose fluidity "); the fluidity in acetone solution of the nitrocellulose derived from the modified cellulose by a standardized procedure (called the " nitrocellulose fluidity "); and, in the case of chemically modified yarns, the single-thread breaking load.

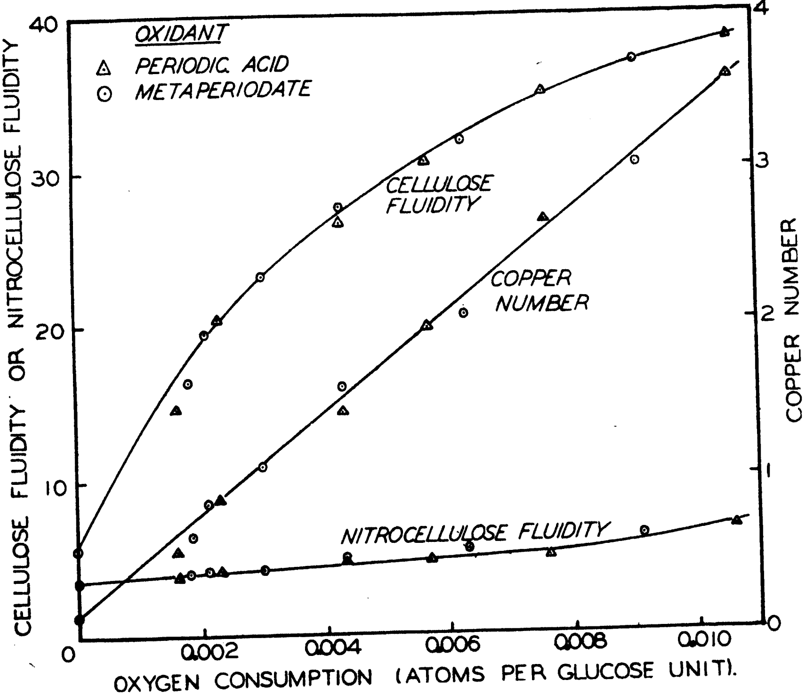


Fig. 1

Earlier studies of the properties of chemically modified cotton cellulose in these laboratories have generally been concerned with the very early stages of modification, corresponding in the case of oxycelluloses, for example, to a consumption of oxygen not exceeding one atom to every thirty or forty glucose units, and it is precisely in these early stages that the property of alkali-sensitivity is most strikingly displayed. Accordingly, the present paper, which is mainly concerned with the alkali-sensitivity of periodic acid and metaperiodate oxycelluloses, deals only with products falling within this restricted range of modification. It is evident that a study of the extent to which oxidation with periodic acid follows the course represented by the above equation would be facilitated by the investigation of a much wider range of oxidative attack, and the results of such an investigation will be presented in a later paper.

DESCRIPTION AND DISCUSSION OF RESULTS

Cellulose Fluidity, Nitrocellulose Fluidity and the Effect of Alkalis on them.

From the results of previous work[8] it is possible to conceive an ideal type of oxycellulose in which oxidation has rendered some of the linkages between the glucose units susceptible to rupture by the action of alkalis, without effecting scission of the chain-molecules. Such oxycelluloses would have the same nitrocellulose fluidity and tensile strength as the unoxidized cellulose from which they were prepared, if, as has been suggested, these properties are determined by the length of the chain-molecules. Owing, however, to the presence of the alkali-sensitive linkages, their fluidity in the alkaline solvent cuprammonium would increase with increasing degree of oxidation. On treatment of the oxycellulose with alkaline solutions devoid of solvent power the nitrocellulose fluidity would be increased and the tensile strength diminished. In previous work the nearest approach to this ideal type was represented by the products of the action of dichromate in the presence of oxalic acid, whereas the acidic oxycelluloses obtained by the action of alkaline hypochlorite or hypobromite were found to be substantially free from alkali-sensitive linkages. The simplest examples of modified celluloses not displaying alkali-sensitivity are, however, provided by the hydrocelluloses, the products of the hydrolytic action of acids.

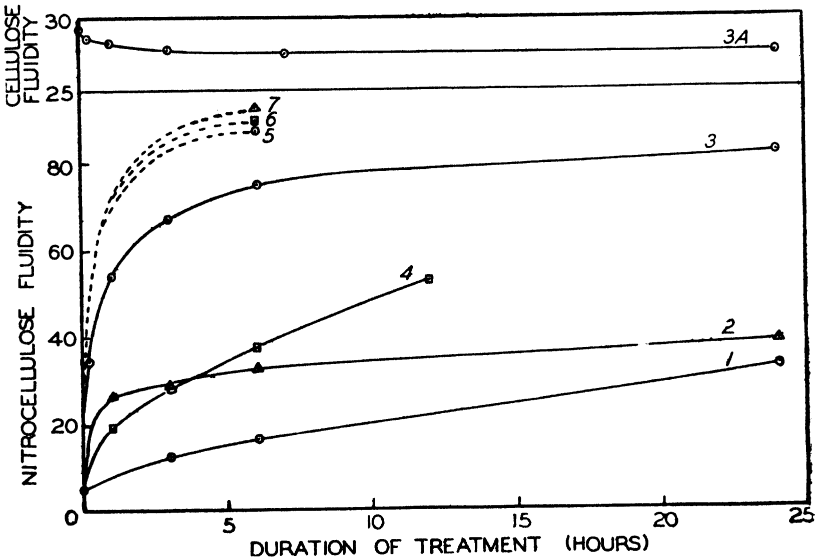


Fig. 2.

Curves 1-7: Effect on nitrocellulose fluidity of treatment with:—
(1) 0·05 *M* borax at 20° C.
(2) Ammonia, 200g./litre at 20° C.
(3) 0·1 *N* sodium hydroxide at 20° C.
(4) Water at 100° C.
(5) 1% soap at 100° C.
(6) 0.1 *M* sodium carbonate at 100° C.
(7) 0·25 *N* sodium hydroxide at 126 °C.

Curve 3A: Effect on cellulose fluidity of treatment with 0.1*N* sodium hydroxide at 20° C.

The extreme alkali-sensitivity of the periodic acid oxycelluloses is immediately evident from a comparison of the curves in Figure 1 that show the cellulose fluidity and the nitrocellulose fluidity of oxycelluloses prepared from cotton linters in relation to the oxygen consumption during the oxidation ; whereas the cellulose fluidity rises rapidly with increasing degree of oxidation, the nitrocellulose fluidity does not increase much above that of the unoxidized cotton. In order to gain some kind of quantitative idea of the relative rates of change of these two properties, it is of course necessary to express them in a form, such as that of relative viscosity, which takes account of the flow properties of the two solvents used. For example, the consumption of one atom of oxygen per 100 glucose units depresses the relative viscosity of a 0·5 per cent. solution of the cellulose in cuprammonium from about 13 to 2. The same oxygen consumption depresses the relative viscosity of a 0·25 per cent. solution of the derived nitrocellulose in acetone from about 86 to 50—a very much

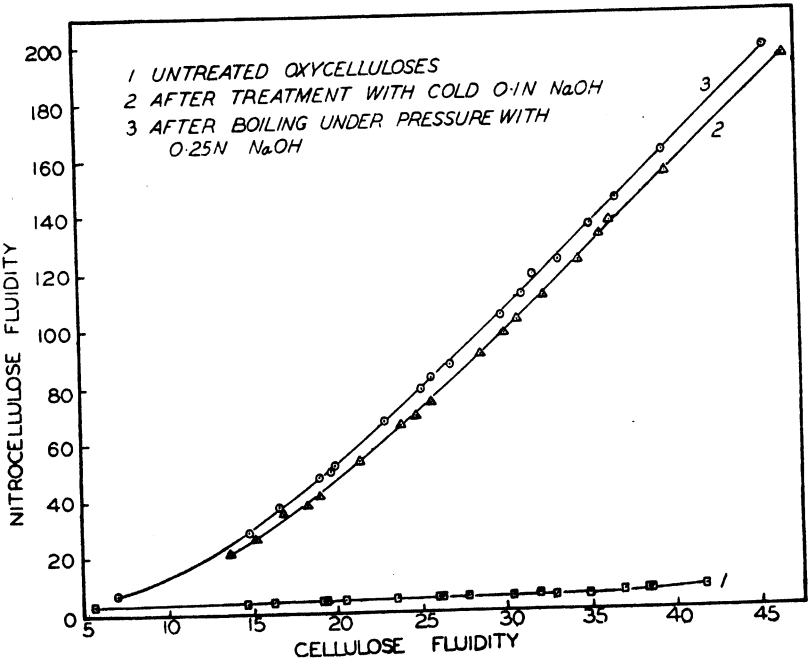


Fig. 3

smaller effect. In modified cottons containing no alkali-sensitive linkages (e.g., hydrocelluloses) a range of relative viscosities from 13 to 2 for the modified celluloses corresponds to the range from 86 to 2 for the derived nitrocelluloses.

The great alkali-sensitivity produced by periodic acid oxidation is most clearly seen, however, in the effects produced on the nitrocellulose fluidity by treatment of the oxycellulose with alkaline solutions prior to nitration. This is illustrated in Fig. 2, in which the nitrocellulose fluidity is plotted against the duration of different alkaline treatments. Even such mild conditions as treatment with 0·05 *M* borax at 20° C. (Curve 1) cause considerable rises of nitrocellulose fluidity, and 0·1 *N* sodium hydroxide at 20° C. (Curve 3) produces a very large and rapid increase comparable with, if not quite so pronounced as, the effects produced by alkaline solutions at high temperatures (Curves 5, 6, 7) ; even boiling the oxycellulose with water results in a steadily rising nitrocellulose fluidity (Curve 4). The effect of concentrated ammonia at 20° C. (Curve 2), is, however, much smaller than would be expected from the alkalinity of the solution, a behaviour similar to that already observed with other types of alkali-sensitive oxycellulose[8]. Curve 3A in Fig. 2 shows the effect of 0·1 N sodium hydroxide at 20° C. on the cellulose fluidity of the oxycellulose, and should be compared with Curve 3, which shows the concurrent effect on the nitrocellulose fluidity. This alkaline treatment has little influence on the cellulose fluidity, the observed change being actually a slight fall. This slight diminution of cellulose fluidity, which also occurs as a result of the hot alkaline treatments (Table III) has not been observed with slightly modified celluloses of any other type, and no adequate explanation of it can be given.

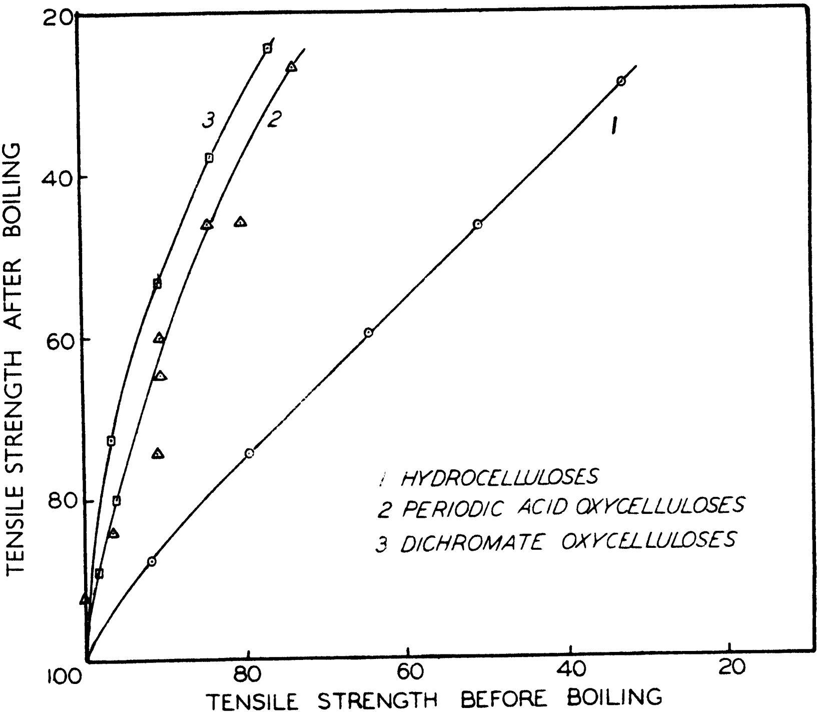


Fig. 4

From the results already given, it is evident that the relation between cellulose fluidity and nitrocellulose fluidity must be greatly affected by the treatment of periodic acid oxycelluloses with alkali, and this is illustrated in Fig. 3. Curves 1 and 2 show the relation between these two properties before and after treatment of the oxycelluloses with 0·1 N sodium hydroxide at 20° C. for 24 hours, and Curve 3, which is not very different from Curve 2, expresses the relation for the materials after boiling with 0·25 N sodium hydroxide for six hours at a pressure 20 lb. per sq. inch in excess of atmospheric (126° C.). The curve for the boiled oxycelluloses (Curve 3) agrees closely with the curve previously found for alkali-boiled oxycelluloses of six different types, and for hydrocelluloses, whether alkali-boiled or not. Thus the inclusion of the periodic acid oxycelluloses does not affect the validity of the generalization that there is a unique relation between cellulose fluidity and nitrocellulose fluidity for all the products of chemical modification of cotton cellulose after they have been boiled with dilute sodium hydroxide solution.

Figs. 1 and 3 include results obtained with metaperiodate oxycelluloses, and they show that with respect to the relations illustrated these products are indistinguishable from oxycelluloses prepared by the action of periodic acid.

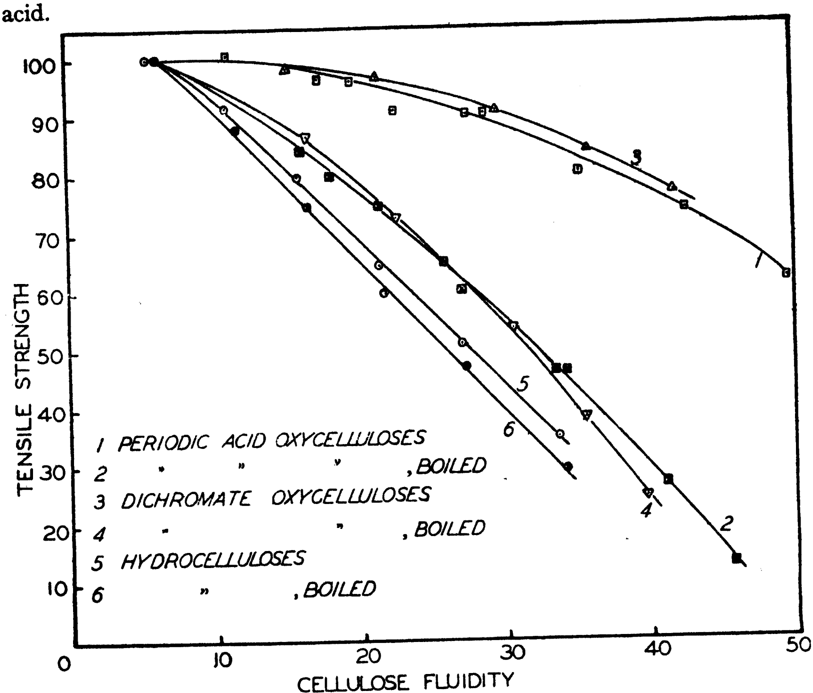


Fig. 5

The Effect of Alkalis on Tensile Strength, and the Relations between Strength and Fluidity.

The effect of alkalis on the tensile strength of periodic acid oxycelluloses and the relations between strength, cellulose fluidity and nitrocellulose fluidity, before and after boiling with sodium hydroxide solution (0·25 *N*, 1 hour), have been studied on yarn modified by oxidation with periodic acid. The results obtained have been compared with those given by yarns modified by the action of hydrochloric acid and by oxidation with dichromate in the presence of oxalic acid. The relations between cellulose fluidity and nitrocellulose fluidity found for the modified yarns are in agreement with those found for the corresponding modified celluloses prepared from linters, so that these relations need not be further discussed.

The alkali-sensitivity of periodic acid oxycelluloses is clearly shown by the effect of alkali-boiling on the tensile strength. The results, which are illustrated in Fig. 4, show that whereas the strength of the acid-modified yarn is only slightly diminished by boiling (Curve 1), the yarns oxidized by periodic acid suffer a great additional loss of strength (Curve 2). This loss is, however, slightly less than that suffered by the dichromate oxycelluloses (Curve 3).

The relation between cellulose fluidity and strength for periodic acid oxycelluloses (Fig. 5, Curve 1) is very similar to that for the dichromate oxycelluloses (Fig. 5, Curve 3), and for a given cellulose fluidity both these types of oxycellulose are much stronger than cotton modified by acid (Fig. 5, Curve 5). When the acid-modified yarns are alkali-boiled the changes of fluidity and strength are so small that the relation between the two properties is not greatly affected (Fig. 5, Curve 6). With the periodic acid and dichromate oxycelluloses, on the other hand, the great falls in strength produced by alkali-boiling are accompanied by relatively slight changes in cellulose fluidity, so that the curves relating cellulose fluidity and strength (Fig. 5, Curves 2 and 4) approach the hydrocellulose curve. The results thus confirm the finding of Clibbens and Ridge[4] that, if the relation between the cellulose fluidity and the strength of acid-modified cotton is taken as the basis of judgment, the cellulose fluidity of the alkali-sensitive oxycelluloses indicates approximately the total loss of strength resulting from oxidation and subsequent treatment with alkali.

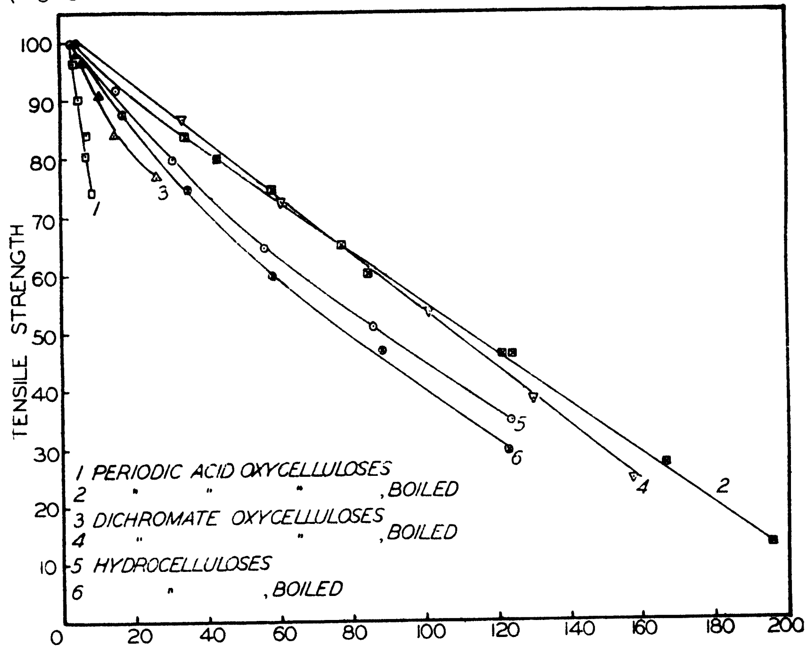


Fig. 6

While no unique relation between cellulose fluidity and tensile strength was to be expected for the whole group of chemically modified cottons owing to the effect of the alkaline solvent on the alkali-sensitive oxycelluloses, it was thought possible that such a relation might exist between nitrocellulose fluidity and strength. This possibility was suggested by the theoretical assumption that both these latter properties might be uniquely determined by the same function of molecular chain-length distribution, and received some experimental support from data previously published, which included results for the alkali-sensitive dichromate oxycelluloses.[3] The results now obtained show conclusively, however, that there is no unique relation between strength and nitrocellulose fluidity. For a given nitrocellulose fluidity, both periodic acid and dichromate oxycelluloses (Fig. 6, Curves 1 and 3) are weaker than cotton modified by acid (Fig. 6, Curve 5), and the difference is considerably greater for the periodic acid than for the dichromate oxycelluloses. On the other hand, after alkali-boiling, the oxycelluloses (Fig. 6, Curves 2 and 4) are stronger than hydrocelluloses of equal fluidity. The direction of the curve for unboiled periodic acid oxycelluloses suggests that the divergence between the fluidity-strength relations for hydrocelluloses and periodic acid oxycelluloses would increase with increasing degree of modification, but an extension of the curve beyond a fluidity of 10 cannot be realized on account of the incomplete solubility in acetone of the nitrocelluloses derived from more highly modified periodic acid oxycelluloses. From an examination of the then existing data, it was stated in an earlier paper[3] that there is a much closer approach to a general fluidity-strength relation, applicable to all methods of modification, when nitrocellulose fluidity is used than when cellulose fluidity is used. In view of the abnormal behaviour of the periodic acid oxycelluloses, this statement loses much of its force.

In another series of experiments the effect of various treatments on the tensile strength, cellulose fluidity and nitrocellulose fluidity of a yarn oxidized by periodic acid was examined. The results given in Table I show that treatment with cold dilute sodium carbonate or sodium hydroxide solution for 6 hours or boiling with borax or soap solution for one hour produce almost as great a loss of strength as the severe treatment of boiling with sodium hydroxide solution, but that the effect of boiling with water or treatment with cold borax solution is relatively small. The effect of concentrated ammonia on strength, like its effect on nitrocellulose fluidity, is considerably less than would be expected. Table I also shows that the tensile strength of the treated oxycelluloses is closely correlated with the nitrocelluloses fluidity, whereas there is no correlation with the cellulose fluidity, which is not very different whatever the treatment.

Table I.

Effect of Various Treatments on Tensile Strength and Fluidity of a Periodic Acid Oxycellulose.

TREATMENT			Relative breaking load	Cellulose fluidity	Nitro-cellulose fluidity
Solution	Temperature (°C.)	Time (hours)			
Unoxidized Yarn :—	—	—	100·0	5·3	3·3
Oxidized Yarn :—	—	—	83·8	38·9	8·7
Borax, 0·05 *M*	20	6	74·5	38·7	30·0
Ammonia, 200 g/l. ...	20	6	65·3	38·3	56·7
Na_2CO_3, 0·1 *M*	20	6	47·8	37·1	113·3
NaOH, 0·1 *N*	20	6	48·3	36·8	121·9
Water	100	1	77·7	38·7	34·5
Borax, 0·05 *M*	100	1	46·9	36·6	125·1
Soap, 0·1%	100	1	47·2	37·3	127·8
Na_2CO_3, 0·1 *M*	100	1	43·7	37·1	134·3
NaOH, 0·25 *N*	100	1	41·0	36·8	136·4
NaOH, 0·25 *N*	100	6	40·2	37·2	136·6

Copper Number and Methylene Blue Absorption.

When cotton is treated with a dilute solution of periodic acid or metaperiodate the copper number rises rapidly, whereas the Methylene Blue absorption remains unchanged (Table II). The relation between copper number and oxygen consumption, which is illustrated in Fig. 1, is very nearly linear, and it is the same whether oxidation is by periodic acid or metaperiodate. These results indicate that the oxycelluloses produced are of the extreme reducing type, and this is in accord with the aldehydic character of the oxidation product formulated in Equation (1).

The Effect of Alkalis on Copper Number.

Treatment of a slightly modified periodic acid oxycellulose with 0·1 *N* sodium hydroxide for 24 hours at 20° C. produces only a slight fall of copper number. Boiling with water for 6 hours also produces little change, but as the severity of the boil is progressively increased, by the use of more alkaline media (soap, sodium carbonate, sodium hydroxide solutions) or of pressure above atmospheric, the fall in copper number increases, until after a pressure boil with 0·25 *N* sodium hydroxide solution the reducing power is no greater than that of the original unmodified cotton (Table IV). The changes of copper number and the concurrent losses of weight produced by hot and cold sodium hydroxide solutions are of particular interest, and they may be illustrated by the following examples. From an initial value of 1·62, the copper number of a periodic acid oxycellulose was reduced to 0·13 by a pressure boil with 0·25 *N* sodium hydroxide, but only to 1·43 by the cold alkaline treatment; the corresponding losses of weight were more than 10 per cent. for the pressure boil (the observed value for treatment at 100° C. was 10·5 per cent.), and only 0·5 per cent. for the cold treatment. It has been seen that the relative effects of the hot and the cold treatments on nitrocellulose fluidity and tensile strength are very different from this, since the changes in these properties produced by the cold treatment are only slightly less than the large changes produced by the hot.

The fall in copper number in the hot alkaline treatments is due to the destruction of aldehyde groups, which is the general action of hot alkalis on reducing carbohydrates. The changes in strength and nitrocellulose fluidity, produced by hot and cold alkaline treatments alike, are ascribed to the rupture of linkages in the cellulose chain-molecules rendered susceptible to cleavage by alkalis on account of oxidative attack at points adjacent to them. These are the changes that characterize what has been called alkali-sensitivity, and they are not intimately associated with the destruction of reducing groups that may or may not occur simultaneously, according to the nature of the alkaline treatment.

The Stability of Periodic Acid Oxycelluloses Towards Acids.

The hypothesis that linkages in the chain-molecules of cellulose may be rendered unstable towards alkalis by oxidative attack makes it pertinent to inquire into the stability of the postulated alkali-sensitive linkages towards acids. This may be investigated by comparing the changes of nitrocellulose fluidity produced by an acid treatment of a periodic acid oxycellulose and of an unmodified cotton. The oxycellulose employed in one experiment of this kind had a cellulose fluidity of 29·2 and a nitrocellulose fluidity of 5·19, the latter being increased to 81·6 by treatment of the oxycellulose with 0·1 *N* sodium hydroxide for 24 hours at 20° C. As a result of treatment with

N-hydrochloric acid for 24 hours at 20° C. the nitrocellulose fluidities of the oxycellulose and the unmodified cotton were increased from 5·19 to 15·3 and from 3·60 to 10·7 respectively. The increase is thus only slightly greater for the oxycellulose than for the unmodified cotton, which shows that the alkali-sensitive linkages are not much more susceptible to acid hydrolysis than the normal glycosidic linkages of cellulose.

EXPERIMENTAL

Methods.

(*a*) *Preparation of Modified Cottons.*

The starting materials used for the preparation of chemically modified cottons were : (1) a sample of cotton linters that had been purified industrially by boiling under pressure with dilute sodium hydroxide solution ; (2) a 3/90's gassed, super-combed hosiery yarn, boiled for 5½ hours with 2 per cent. sodium hydroxide solution at a pressure 40 lb. per sq. inch in excess of atmospheric, and bleached by treatment for an hour with *N*/25 sodium hypochlorite at *p*H 11·3.

Periodic acid is a polybasic acid ; its first dissociation constant, as calculated by Rothmund and Drucker[5] from conductivity data, is $2{\cdot}3 \times 10^{-2}$ and the second has been found, by potentiometric titration with the glass electrode, to be approximately 10^{-8}. The salts described as metaperiodates behave in solution as the primary salts of the polybasic acid, and their dilute solutions have a *p*H of about 5·3. Metaperiodate oxycelluloses were prepared by treating the cotton at 20° C. with a 0·01 *M* solution of potassium metaperiodate, and periodic acid oxycelluloses were obtained by means of 0·005 or 0·01 *M* solutions of this salt containing an equivalent amount of sulphuric acid. The ratio of cotton to solution was 20 grams per litre in the oxidation of the linters, and about 2·5 grams per litre with the yarn. The oxygen consumption during the oxidation of the linters was calculated from the change of concentration of the oxidizing solution, any fall in concentration due to oxidation of non-cellulosic impurities or to preferential adsorption of the oxidant by the cotton being neglected. The concentration of the periodate solutions was determined by the method of Müller and Friedberger[6] for the estimation of periodate in the presence of iodate, the procedure employed being as follows : to 25 c.c. of the periodate solution 10 c.c. of saturated sodium bicarbonate solution was added, followed by 10 c.c. of 10 per cent. potassium iodide solution, and the liberated iodine was titrated with 0·02*N* arsenite, with starch solution as indicator.

The acid-modified yarns were prepared by steeping in hydrochloric acid (200g. per litre) at 20° C. and modification by dichromate was effected by steeping the yarn in mixtures of oxalic acid and potassium dichromate solutions until reduction of the dichromate was complete.

(*b*) *Measurement of Properties of Modified Cottons.*

Copper numbers were determined by the Schwalbe-Braidy method, the procedure being that described by Clibbens and Geake.[7]

The absorption of Methylene Blue was measured by the titrimetric method described by Birtwell, Clibbens and Ridge,[8] a neutral buffered solution of the dye being used.[9] The results given are based on the absorption by 2·5 g. of oxycellulose from 15 c.c. of 0·004 *M* solution, and are expressed as millimoles of Methylene Blue absorbed per 100 g. of dry material.

The fluidity in cuprammonium, referred to in the foregoing discussion as the " cellulose fluidity ", was measured by the method of Clibbens and Geake,[10, 11, 12] but fluidities higher than about 35 were determined in a modified form of the standard viscometer with a longer and narrower capillary. In this way the large kinetic energy corrections involved in measurements in this range with the standard instrument were avoided. The values recorded are the fluidities in absolute units of 0·5 per cent. solutions of cellulose at 20° C.

Nitrocelluloses were prepared from the modified cottons by nitration with a mixture of nitric acid, phosphoric acid and phosphorus pentoxide and the fluidities of the nitrocelluloses in acetone solution determined according to the methods recently described.[3] The fluidities given are those of 0·25 per cent. nitrocellulose solutions at 20° C. and they are expressed in absolute units.

The breaking load of the yarns was determined by means of the Goodbrand single-thread tester. The " cut skein " method of sampling was employed, and the procedure followed in comparing the effects of a number of treatments on the tensile strength was similar to that described in detail by Clibbens and Ridge.[4] Each sample consisted of 100 threads, and the breaking loads were determined on 15 cm. lengths. The testing was carried out at 65–70° F. and 65 per cent. relative humidity.

Results.

(a) *The Properties of Periodic Acid and Metaperiodate Oxycelluloses Prepared from Linters.*

The properties of three series of oxycelluloses in relation to duration of oxidation and oxygen consumption are given in Table II. The relation of oxygen consumption to copper number, cellulose fluidity and nitrocellulose fluidity are shown graphically in Fig. 1.

Table II.

Properties of Periodic Acid and Metaperiodate Oxycelluloses.

Conditions of oxidation	Time of oxidation (hours)	Oxygen consumption (Atoms oxygen per glucose unit)	Cellulose fluidity	Nitro-cellulose fluidity	Copper number	Methylene Blue absorption
$0.005M$ KIO_4, $0.005N$ H_2SO_4; 20°C.	0	0	5·6	3·60	0·14	1·12
	0·5	0·0016	14·6	3·79	0·54	1·11
	1·0	0·0023	20·4	4·19	0·87	1·12
	2·0	0·0043	26·5	4·68	1·43	1·11
	3·0	0·0057	30·4	4·80	1·97	1·12
	4·5	0·0076	34·8	4·93	2·66	1·11
	7·0	0·0106	38·3	6·62	3·57	1·11
$0.01M$ KIO_4, $0.01N$ H_2SO_4; 20°C.	0·5	0·0026	19·1	3·82	—	—
	1·0	0·0046	26·0	4·29	—	—
	2·0	0·0075	32·9	4·80	—	—
	3·5	0·0112	38·5	6·49	—	—
	5·05	0·0143	41·6	7·62	—	—
	16·1	0·0313	48·8	*	—	—
$0.01M$ KIO_4; 20°C.	0·5	0·0018	16·3	3·97	0·63	1·12
	0·7	0·0021	19·5	4·18	0·84	1·12
	1·1	0·0030	23·3	4·32	1·09	1·15
	1·6	0·0043	27·6	4·93	1·60	1·11
	2·5	0·0063	31·8	5·51	2·05	1·13
	4·0	0·0091	36·9	6·15	3·02	1·14

* Nitrocellulose only partially soluble.

Table III.
Effect of Treatment with Sodium Hydroxide Solution on Cellulose Fluidity and Nitrocellulose Fluidity of Periodic Acid and Metaperiodate Oxycelluloses.

Oxidant	Untreated oxycellulose		After treatment with 0·1 *N* NaOH at 20° C. for 24 hours		After boiling with 0·25 *N* NaOH at excess pressure of 20 lb./sq. inch for 6 hours	
	F_C	F_N	F_C	F_N	F_C	F_N
0·005*M* KIO_4, 0·005 *N* H_2SO_4	5·6	3·60	—	—	6·8	7·2
	14·6	3·79	13·5	20·8	14·8	28.6
	20.4	4·19	19·1	40·3	20·0	51·6
	26·5	4·68	24·8	68·2	25·7	82·0
	30·4	4·80	28·6	89·8	29·9	103·7
	34·8	4·93	32·6	110·6	33·5	122·9
	38·3	6·62	35·8	131·3	36·8	144·0
0·01 *M* KIO_4, 0·01 *N* H_2SO_4	19·1	3·82	16·9	35·6	19·0	47·5
	26·0	4·29	23·8	65·1	25·1	78·3
	32·9	4·80	30·9	101·8	31·9	118·1
	38·5	6·49	36·4	135·1	36·9	142·3
	41·6	7·62	39·7	152·4	39·7	160·4
	48·8	*	46·8	193·2	45·9	198·0
0·01 *M* KIO_4	16·3	3·97	15·1	25·9	16·6	36·9
	19·5	4·18	18·3	37·7	19·4	49·7
	23·3	4·32	21·4	53·0	22·8	66·3
	27·6	4·93	25·6	73·0	26·8	86·1
	31·8	5·51	29·9	96·8	31·0	109·8
	36·9	6·15	34·6	122·2	35·2	134·7

F_C, cellulose fluidity ; F_N, nitrocellulose fluidity. * Nitrocellulose only partially soluble.

Table IV.
Effect of Various Treatments on Properties of a Periodic Acid Oxycellulose.
(Oxygen consumption, 0.0052 atom per glucose unit)

TREATMENT :			Cellulose fluidity	Nitro-cellulose fluidity	Copper number	Methylene Blue absorption
Solution	Temp- (°C.)	Time (hours)				
Original oxycellulose ...	—	—	29·2	5·19	1·62	1·12
NaOH, 0·1 *N* ...	20	0·25	28·6	34·5	—	—
	,,	1·0	28·3	54·0	—	—
	,,	3·0	27·8	66·9	—	—
	,,	6·0	27·5	74·9	—	—
	,,	24·0	27·5	81·6	1·43	1·14
Ammonia, 200 g/l.	20	1·0	28·5	26·1	—	—
	,,	3·0	28·7	28·8	—	—
	,,	6·0	29·2	33·0	—	—
	,,	24·0	28·8	38·8	—	—
NaOH, 0·1 *N*+ ammonia, 200 g/l.	20	4·0	29·1	62·8	—	—
	,,	24·0	29·0	71·4	—	—
Borax, 0·05 *M* ...	20	3·0	29·0	12·8	—	—
	,,	6·0	29·2	16·4	—	—
	,,	24·0	29·1	32·9	—	—
Water	100	1·0	29·6	18·9	—	—
	,,	3·0	28·9	28·2	—	—
	,,	6·0	30·1	37·7	1·52	0·88
	,,	12·0	30·0	53·5	—	—
Soap, 1%	100	6·0	27·5	87·5	1·19	0·89
Na_2CO_3, 0·1 *M*	100	6·0	27·3	89·5	0·70	1·19
NaOH, 0·25 *N*	126*	6·0	27·7	92·9	0·13	1·20

* 20 lb./sq. inch excess pressure.

(*b*) *Effect of Alkalis on Cellulose Fluidity, Nitrocellulose Fluidity, Copper Number and Methylene Blue Absorption.*

Table III shows the effect on the cellulose fluidity and the nitrocellulose fluidity when the oxycelluloses described in Table II were (*a*) treated with 0·1 *N* sodium hydroxide for 24 hours at 20° C., (*b*) boiled for 6 hours with 0·25 *N* sodium hydroxide under a pressure 20 lb. per sq. inch above atmospheric. The relation between cellulose fluidity and nitrocellulose fluidity, before and after these treatments, is represented graphically in Fig. 3.

The changes in the cellulose fluidity, nitrocellulose fluidity, copper number and Methylene Blue absorption produced by these and other treatments in a periodic acid oxycellulose are recorded in Table IV, and some of the data are illustrated in Fig. 2.

Table V.

Breaking Load, Cellulose Fluidity and Nitrocellulose Fluidity of Chemically Modified Yarns, before and after Boiling with Alkali.

	Before boiling			After boiling for 1 hour with 0·25 *N* NaOH		
Material	Cellulose fluidity	Nitro-cellulose fluidity	Relative breaking load	Cellulose fluidity	Nitro-cellulose fluidity	Relative breaking load
Unmodified yarn	5·3	3·33	100·0	6·1	4·99	100·0
Yarn modified with HCl (200 g/litre) at 20° C.	10·9	15·9	91·7	11·7	17·7	87·7
	15·9	31·4	79·7	16·5	35·1	74·5
	21·4	56·3	64·4	21·7	58·4	59·7
	27·0	86·8	50·8	27·3	88·5	46·6
	33·6	123·8	34·6	34·1	123·0	29·1
Yarn modified with 0·005 *M* KIO_4, 0·005 *N* in H_2SO_4, at 20° C.	11·1	3·76	100·6	10·8	17·0	91·9
	17·4	4·03	96·4	16·1	34·6	83·9
	22·5	4·26	91·0	21·4	58·4	74·5
	28·7	5·79	90·4	27·0	87·0	60·0
	35·2	7·54	80·2	33·5	121·5	45·8
Do.	19·6	4·26	96·0	18·2	43·3	79·8
	27·6	5·14	90·3	25·9	77·5	64·8
	35·8	7·77	84·4	34·3	124·0	45·8
	42·5	9·88*	74·1	41·0	166·8	26·9
	49·5	**	61·5	45·6	195·9	12·8
Yarn modified with dichromate and oxalic acid	15·3	5·16	97·9	16·6	33·9	86·5
	21·4	6·46	96·8	22·6	60·9	72·4
	29·6	10·8	90·9	30·6	101·6	53·3
	35·8	15·6	84·0	35·4	129·5	38·0
	41·7	26·5	76·6	39·6	157·4	24·4

* Nitrocellulose not quite completely dissolved.
** Nitrocellulose only partially soluble.

(*c*) *Tensile Strength, Cellulose Fluidity and Nitrocellulose Fluidity of Modified Cottons, and the Effect of Alkalis on these Properties.*

Table V gives the mean single-thread breaking load (expressed as a percentage of that of the unmodified yarn), the cellulose fluidity and the nitrocellulose fluidity of yarns modified by the action of periodic acid, dichromate in the presence of oxalic acid, and hydrochloric acid, together with corresponding data for the same yarns after boiling for an hour with 0·25 *N* sodium hydroxide. This boiling treatment increased the strength of the unmodified yarn by about 3 per cent., and the breaking loads of the modified and boiled yarns are expressed as a percentage of the breaking load of the boiled, unmodified yarn. The effect of boiling with sodium hydroxide solution on the tensile strength of the modified cottons is shown graphically in Fig. 4, and the relations between tensile strength and cellulose fluidity, and between tensile strength and nitrocellulose fluidity are illustrated in Figs. 5 and 6 respectively. The relations between tensile strength and cellulose fluidity for hydrocelluloses and dichromate-oxalic acid oxycelluloses have already been determined by Clibbens and Ridge[4] on another yarn, and their results are in reasonable agreement with those now found. The effects of various other treatments on the strength and fluidity of a periodic acid oxycellulose have already been given in Table I.

SUMMARY

(1) The properties of oxycelluloses formed in the early stages of the oxidation of cotton cellulose by periodic acid and potassium metaperiodate have been studied and compared with those of other types of chemically modified cellulose previously examined.

(2) Within the range of oxidative attack investigated (oxygen consumptions not exceeding one atom to every hundred glucose units), the copper number of the periodic acid oxycelluloses is proportional to the oxygen consumption.

(3) The absorption of Methylene Blue by cotton cellulose is not appreciably affected by periodic acid oxidation within the stated range.

(4) Periodic acid oxycelluloses exhibit the property of alkali-sensitivity in an extreme degree. As a result of treatment of the oxycelluloses with dilute alkalis their nitrocellulose fluidity (fluidity of derived nitrocelluloses in acetone solution) may be greatly increased and their tensile strength greatly diminished.

(5) The nitrocellulose fluidity of a periodic acid oxycellulose is only slightly greater than that of the original cotton, and is thus much less than that of a hydrocellulose of equal cellulose fluidity (in cuprammonium solution) ; after alkali-boiling, however, the periodic acid oxycelluloses show the same relation between cellulose fluidity and nitrocellulose fluidity as hydrocelluloses and alkali-boiled oxycelluloses of other types.

(6) Periodic acid oxcyelluloses resemble the dichromate oxycelluloses in being considerably stronger than hydrocelluloses of equal cellulose fluidity, but after alkali-boiling the relation between cellulose fluidity and tensile strength is much more nearly the same for all these types of modified cellulose.

(7) Periodic acid oxycelluloses are considerably weaker than dichromate oxycelluloses of equal nitrocellulose fluidity and the relation between the tensile strength and the nitrocellulose fluidity of modified celluloses varies with the method of modification more than was previously thought.

(8) Oxidation of cotton cellulose by potassium metaperiodate solutions (pH 5·3) yields oxycelluloses which are indistinguishable from those produced by the action of periodic acid.

(9) Evidence is adduced to show that the increase of nitrocellulose fluidity or fall of tensile strength produced by the action of alkalis on periodic acid oxycelluloses is not intimately connected with destruction of reducing groups which may accompany it.

(10) The results which show the alkali-sensitivity of periodic acid oxycelluloses are interpreted as an indication of the presence in the oxidized chain-molecules of linkages that may be broken by alkalis.

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THE JOURNAL OF THE
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TRANSACTIONS

8—A MACHINE FOR THE FINE CUTTING OF LINEN AND COTTON MATERIALS PREPARATORY TO THE DETERMINATION OF SOLUBILITY NUMBER OR OF THE FLUIDITY OF THEIR CUPRAMMONIUM SOLUTIONS.

By D. A. Derrett-Smith and R. J. B. Keig.
(Linen Industry Research Association)

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INTRODUCTION

In the already published description of the details of carrying out the determination of the solubility number of linen (and cotton) materials[1] it was stated that the material in the case of cloth should be cut into very thin shreds (not more than 1 mm. wide) from strips ¼″ wide cut at an angle of 45° to the warp direction; the shreds are then broken down to a powder between finger and thumb. In the case of yarn it was stated that short lengths (less than 1 mm.) should be cut off from the ends of a small bundle, the cut material being then broken down to a powder as before.

The procedure generally adopted has been to cut the material by hand, using a pair of sharp scissors for the purpose. The time thus occupied may be considerable, especially when a large number of routine samples have to be dealt with; in addition, such a procedure becomes tedious.

An alternative method which has been used consists in cutting the material on a hard-wood board by means of a razor. This method, however, also suffers from the disadvantages referred to above.

The machine described below reduces very materially the time taken for cutting the sample and yields a more uniform product than is obtained by means of scissors.

The machine is also useful for cutting linen and cotton materials prior to dissolving in cuprammonium solution for the determination of fluidity.

Description of the Machine

The framework is constructed from steel plates. The general details are shown in Figures 1 and 2 which are respectively front and end elevations, the principal parts (referred to in the following description) being indicated by means of heavier lines.

The material to be cut is introduced into the conductor A, the aperture of which is ½″ wide. In the case of cloth the material should consist of a strip (cut at 45° to the warp direction) ⅜″-7/16″ wide and 5″-6″ in length; rather smaller lengths than this can be used but are less convenient to deal with.* In the case of yarn, a number of separate threads are placed

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* The machine is not adapted for cutting very small samples of material such as short lengths of sewing thread, etc., and in such cases it is necessary to resort to hand-cutting.

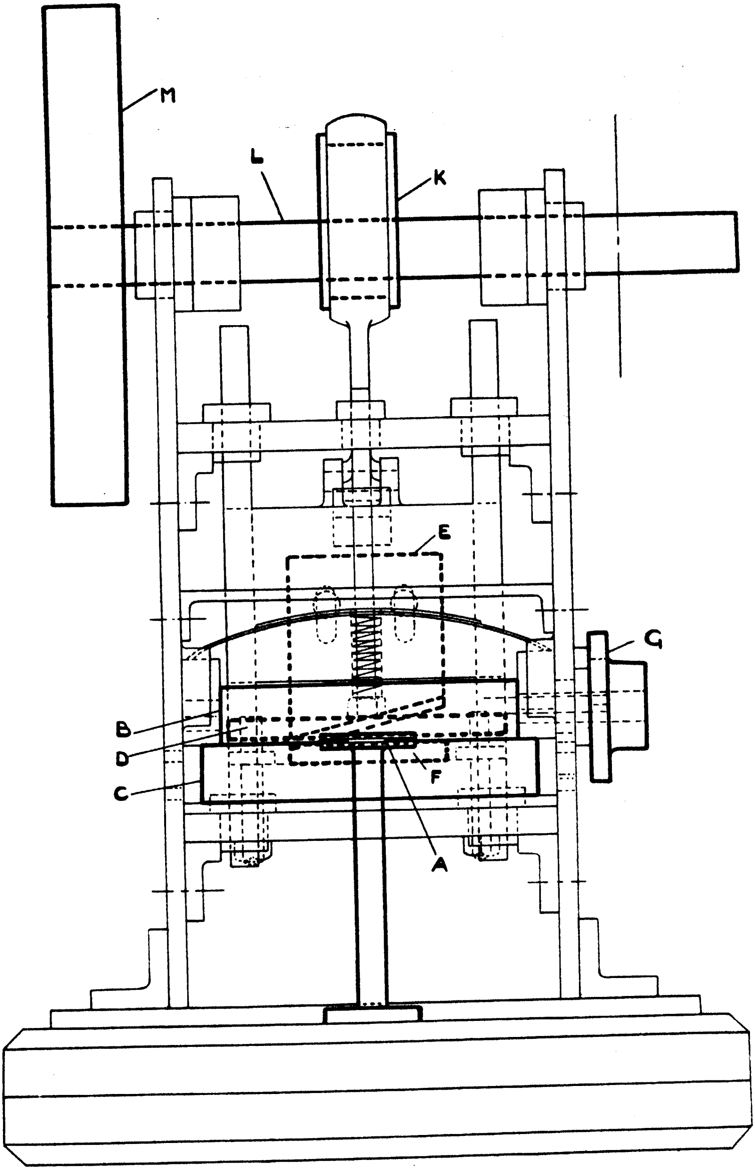

Fig. 1

FRONT ELEVATION

together to form a loose swatch of such a thickness that it will pass easily through the conductor; as before 5″-6″ is a convenient length. The optimum amount of yarn is readily judged with practice.

After passing through the conductor the material is engaged between two stainless steel fluted rollers B, C, ¾″ in diameter, which carry it forward beneath a clamp D to a pair of hardened steel guillotine blades* E, F. The material is automatically advanced in stages by means of a ratchet wheel G provided with a pawl H and spring J and this forward motion determines

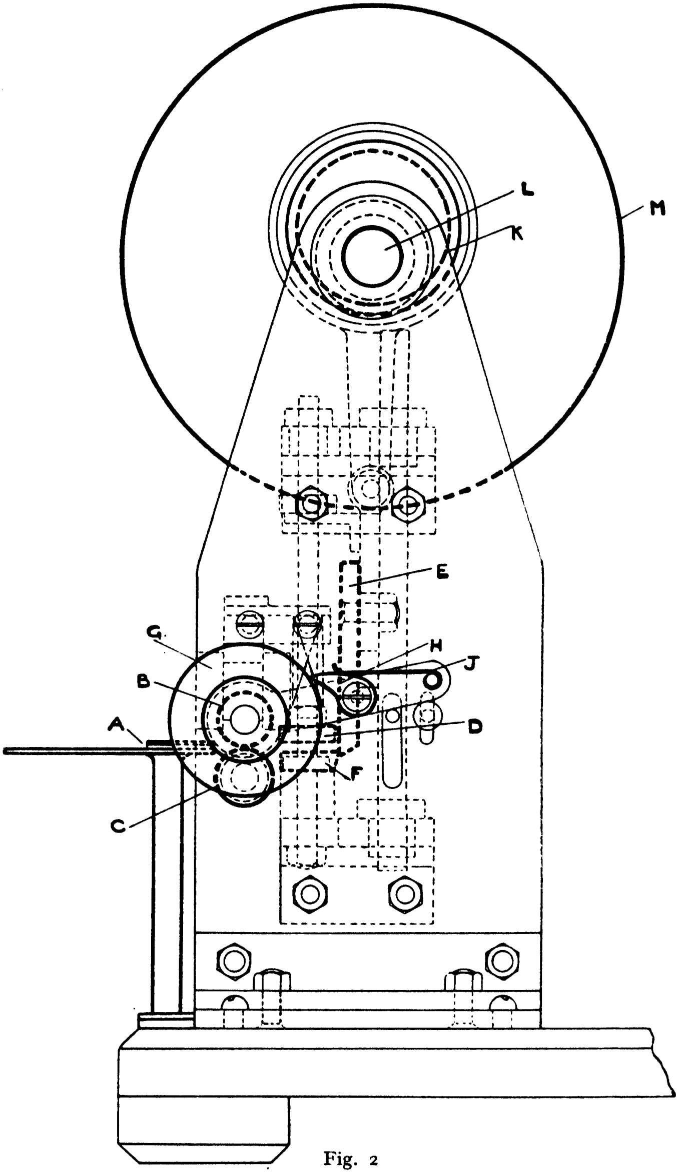

Fig. 2

END ELEVATION

the length of the cutting which in the present machine is fixed at approximately 0·4 mm. (0·39 mm. actual). Immediately prior to each cutting motion of the blades, the clamp D descends and holds the material firmly against the fixed lower blade F. After the cutting motion has taken place the clamp D is released and the material is moved forward for the next cutting. The action of the upper blade E and the clamp D is effected by means of an eccentric K. The shaft L, to which a flywheel M is attached, may be driven either by hand or by means of an electric motor. A convenient speed of rotation is 200 revolutions, i.e. 200 cuts, per minute.

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* Made by Wm. Ward & Son (Sheffield) Ltd., Centenary Works, Woodseats Road, Sheffield, 8.

Before introducing the material to be cut, the upper blade E is first raised by slowly rotating the shaft. The pawl and spring are released and the material after passage through the conductor is engaged between the fluted rollers and carried forward by turning the ratchet wheel by hand. When a short length of material projects through the blades, the pawl and spring are replaced and the shaft rotated slowly so that the projecting portion of the material is cut off. This trimming is rejected and the cutting of the sample then proceeds. The cut material which is collected on a filter paper placed in a tray is in a slightly compressed condition but is readily reduced to a loose uniform powder by rubbing between the finger and thumb or between hard filter paper.

It is essential that the moving parts of the machine, especially those in the neighbourhood of the blades, should be kept free from excess lubricating oil. All remnants of the previous sample should be removed before cutting the next sample, and this is conveniently and rapidly effected by means of a jet of compressed air.

Several hundred solubility number determinations have now been carried out, using material cut by the machine and the performance of the latter has proved very satisfactory.

The following table gives the results of comparative solubility number determinations carried out on a selection of samples cut by scissors and by the machine in each case.

Table I.

Comparison of Results of Solubility Number Determinations made by cutting the material by hand with scissors and by the machine.

Linen Sample No.	Solubility Number cut by	
	Scissors	Machine
1	5·1	5·1
3249	5·9	5·9
1A	6·0	6·0
1609	8·5	8·4
1E	8·9	9·0

These figures show that the results given by each method of cutting may be regarded as the same for any given sample of material.

The fluidity of a solution of cotton material in cuprammonium was shown to be independent of whether the sample is cut by scissors or by the machine. For example:—

Sample	Fluidity 0·5% solution cut by	
	Scissors	Machine
Bleached Cotton Cloth ..	8·5	8·5

REFERENCE

[1] Nodder. *J. Text. Inst.*, 1931, **22**, T416.

Received 2/7/40

9—A NOTE ON MOISTURE CONTENT AND REGAIN CALCULATION CHARTS

By J. Tankard, M.Sc., A.Inst.P., F.T.I.

(*Copyright by Messrs. Tootal Broadhurst Lee Co., Ltd.*)

A moisture content determination graph which enables the value of the moisture content of a sample of timber or wood pulp to be obtained without any mathematical calculation, when the initial weight and the dry weight of the sample have been determined, has been devised by R. A. G. Knight (Bulletin No. 14, Second Edition, Forest Products Research Laboratory). Rectangular co-ordinates graduated on a logarithmic scale are used to indicate the initial and the dry weights of the sample, and the moisture content is indicated by a series of parallel lines inclined at an angle of 45° to the ordinates and the abscissae.

The mathematical principle underlying this device has been explained by S. G. Barker (*J. Text. Inst.*, 1939, **30**, T131), who has devised a direct reading slide rule for the same purpose.

The graph can, of course, be used in connection with moisture determinations on textiles or other hygroscopic materials, but it should be clearly understood that, according to Knight, the moisture content of a sample of timber is the amount of moisture in the sample expressed as a percentage of the weight of dry wood substance in the sample, whereas in the textile industry, this quantity is referred to as the moisture regain.

A similar graph to the one devised by Knight is obtained if the moisture content of a sample of textile material (i.e. the amount of moisture in the sample expressed as a percentage of the total weight of the material, including moisture) is plotted against the initial weight and the dry weight of the sample, the moisture content being indicated by a series of parallel lines inclined at 45° to the ordinates and the abscissae.

It is not practicable to construct a graph of this type which will indicate both the moisture content and the moisture regain of a specimen, since the two series of parallel lines indicating these quantities would overlap.

A further disadvantage of Knight's graph is that all the quantities involved, i.e. the initial weight, the dry weight, and the moisture content (or regain) are indicated on logarithmic scales, thus making accurate interpolation of values difficult.

The nomogram shown in Fig. 1 enables the values of both the moisture content and the regain to be obtained simultaneously, and has the further advantage that all the quantities involved are indicated on uniformly graduated scales. The method of use is illustrated by the following example:—

Initial weight of sample 6·47 gms.; dry weight 5·24 gms. Connect the points on the appropriate scales corresponding to the initial and the dry weights by means of a straight-edge, represented in Fig. 1 by the line AB.

Mark the point C at which the straight-edge intersects the reference line DE marked on the chart. Place the straight-edge so that it passes through the point C and intersects the dry weight scale at the 10·0 graduation. This is represented by the line FG. The required values of the moisture content (19·0 per cent.) and the regain (23·5 per cent.) are read on the appropriate scales at the points where these are intersected by the line FG.

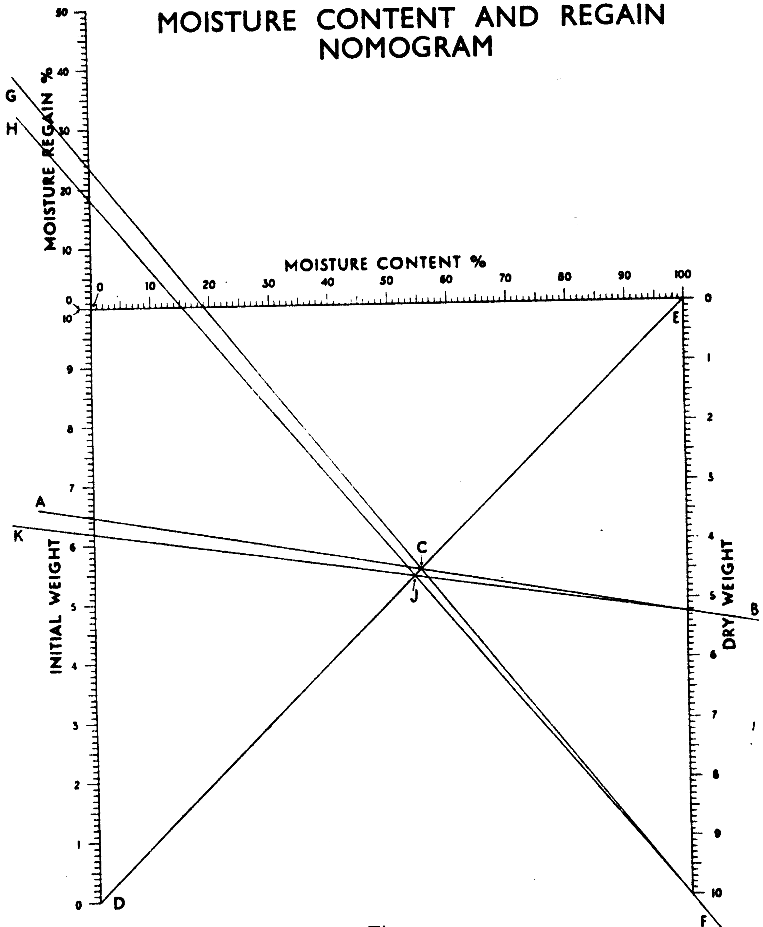

Fig. 1

The "correct condition weight" of the sample can also be determined by means of this nomogram. Assuming that the sample referred to above is a worsted yarn; the normal regain (18¼ per cent.) for this material is represented by the line FH which intersects the reference line DE at J. To determine the "correct condition weight" place a straight-edge on the chart so that it passes through the point J and intersects the dry weight scale at the point corresponding to the known dry weight of the sample. This is represented by the line BK, and the "correct condition weight"

(6·19 gms.) is given by the point at which this line intersects the initial weight scale.

The moisture regain scale in the nomogram shown in Fig. 1 is graduated up to 50 per cent. only. If higher values are being dealt with, this scale can be extended, but it will generally be found more satisfactory to introduce a second regain scale to the right of and parallel to the one shown. The graduations on this second scale will be closer together than those on the scale shown, and the range will be correspondingly greater. The origin of any regain scale will be on a line joining the 10·0 graduations on the initial weight and the dry weight scales.

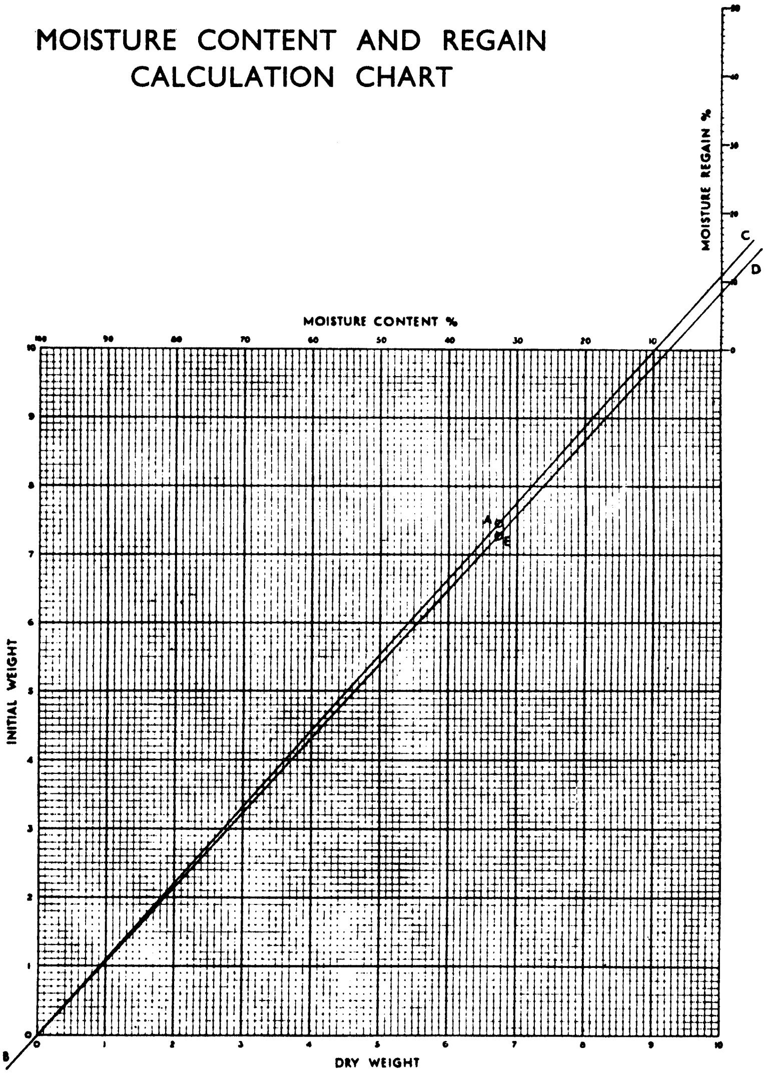

Fig. 2

Another form of moisture content and regain calculation chart which enables the values of both these quantities to be obtained simultaneously without calculation, and in which all the quantities involved are indicated on uniformly graduated scales is shown in Fig. 2. The method of using the chart is as follows:—

Mark the point on the chart corresponding to the initial and dry weights of the sample. Place a straight-edge on the chart so that it passes through this point and also through the origin of the weight scales. The required values of the moisture content and the regain are then read on the appropriate scales at the points where these are intersected by the straight-edge.

Example: Initial weight of sample 7·46 gms.; dry weight 6·72 gms. These quantities are indicated by the point A. The line BC represents the straight-edge passing through A and through the origin of the weight scales. The moisture content (9·9 per cent.) and the regain (11·0 per cent.) are read on the appropriate scales at the points where these are intersected by the line BC.

The " correct condition weight " can also be obtained if a reference line corresponding to the normal regain of the material under examination is marked on the chart. Thus in Fig. 2, the line BD corresponds to the normal regain (8½ per cent.) for cotton materials. The point E corresponding to the known dry weight of the sample is marked on this line, and the " correct condition weight " (7·29 gms.) read on the initial weight scale.

The use of this chart is greatly facilitated if it is mounted on a drawing board or piece of stout card, and a celluloid strip having a fine line drawn along it is mounted on a pivot passing through the origin of the weight scales. It is then only necessary to rotate the strip until the line marked on it passes through the point on the chart corresponding to the initial and dry weights of the sample, and then to read the required value on the appropriate scale.

If values of the moisture regain higher than 50 per cent. are being dealt with, the regain scale shown in Fig. 2 can be extended, or a second scale can be introduced to the left of and parallel to the one shown. The origin of any such scale will be on a line passing through the origin of the weight scales at an angle of 45° to the ordinates and abscissae.

The initial weight and the dry weight scales are marked from 0-10 in the charts shown in Figs. 1 and 2. In the case of samples having an initial weight exceeding 10 units, the decimal points of *both* the initial and the dry weight figures are moved equally to enable the quantities to be read off the appropriate scales, and the result is read off directly as before. Thus initial and dry weights of 75·26 gms. and 65·50 gms. respectively would be treated as 7·526 and 6·550; initial and dry weights of 11·35 gms. and 9·80 gms. would be treated as 1·135 and 0·980. In the case of samples having an initial weight less than 1 unit, the decimal points of *both* the initial and the dry weight figures are moved equally to enable these quantities to be read off in the higher regions of the appropriate scales, and the result is read off directly as before. Thus initial and dry weights of 0·865 gms. and 0·813 gms. would be treated as 8·65 and 8·13.

The charts described in this paper can obviously be used to determine without calculation the value of any one of the quantities x, y or z, in expressions of the type

$$\frac{x-y}{x}=z \text{ or } \frac{x-y}{y}=z$$

provided that the values of the other two quantities are known. The values of x are measured along the " initial weight " scale, and those of y along the " dry weight " scale, the values of $\frac{x-y}{x}$ being shown on the " moisture content " scale and those of $\frac{x-y}{y}$ on the " moisture regain " scale.

SUMMARY

Two charts are described and illustrated, by means of which it is possible to obtain, without any mathematical calculation, the value of any one of the quantities x, y or z in expressions of the type

$$\frac{x-y}{x}=z \text{ or } \frac{x-y}{y}=z$$

when the values of the other two quantities are known. Special reference is made to the use of these charts in determinations of the moisture content and/or moisture regain of textile materials.

Acknowledgment

The author's thanks are due to Mr. F. Hayes for assistance in the preparation of the illustrations.

Received 7/5/40

10—CORRESPONDENCE

To the Editor of the Journal of the Textile Institute.

Section Cutting by a Modified Plate Method

Sir,

In the *J. Text. Inst.*, 1936, **27**, T217, a medium was described for embedding textile fibres before cutting into sections by a " modified plate method ". One of the purposes of this medium was to absorb any light scattered sideways from the fibres, thereby improving their definition. The medium consisted of a mixture of glycerine jelly and Parker's Jet Black Documentary Ink. Since 1936 the method has been in constant use and experience has shown that ordinary liquid Indian ink gives better results than the Parker's ink described previously. The reason for the improvement is that Indian ink, being a dispersion of carbon particles, does not stain any fibres and has a very great opacity.

The improved medium is made up by mixing approximately equal volumes of melted glycerine jelly and liquid Indian ink. It is used exactly as described previously.

(Signed) J. M. PRESTON.

Department of Textile Chemistry,
College of Technology, Manchester 1.

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TRANSACTIONS

11—VARIATIONS OF SHAPE AND AREA OF CROSS-SECTION IN SINGLE SILK FILAMENTS AND THEIR EFFECT UPON EXTENSIBILITY

By A. C. GOODINGS, and L. H. TURL

(Ontario Research Foundation, Canada)

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INTRODUCTION AND SUMMARY

The silk filament shows considerable irregularity along its length in both shape and area of cross-section. Continuous fluctuation is exhibited by variations which occur with a frequency detectable only by microscopic methods, although these may be superimposed upon other variations in cross-sectional area appearing over much longer lengths.

Certain studies of silk require a knowledge of the physical dimensions of the filament. It is of importance in experiments dealing with the elastic properties of filaments to know the area of cross-section and its variations. To obtain information on such variations in silk to be subsequently used in the examination of these properties, a sample of Japanese white silk was examined by the method of serial cross-sections. This silk was selected on the basis of high grading for evenness as determined by inspection on the seriplane ; and apart from the obvious choice of such a sample for the proposed work, the data obtained are of interest as indicating the magnitude of the variations to be encountered in single filaments of a cultivated silk of recognised high grade. Although variations in shape are large, the variations in actual area of cross-section rarely exceed 20 per cent. of the mean.

The form of the load-extension curve for silk filaments lends itself to simple mathematical treatment of the effect of variations in cross-sectional area on the extensibility of these filaments. It is shown that this effect is small, and that experimental curves, reduced to a stress basis, approximate closely to curves for ideally uniform filaments.

Methods for the determination of the mean area of cross-section of filaments have been studied with reference to their application to relatively short segments of silk filaments. The method of weighing is considered to be the simplest and most reliable, and details are given of a micro-balance suitable for this purpose.

VARIATIONS OF SHAPE AND AREA OF CROSS-SECTION IN SINGLE FILAMENTS OF SILK

The investigation of the variations of shape and area of cross-section was made by a study of contours drawn from serial cross-sections of 20μ thickness with the camera lucida. Although the amount of time and labour involved in this method was extremely great, it was felt that only by such a procedure could the required definite information concerning the form of the filament be obtained.

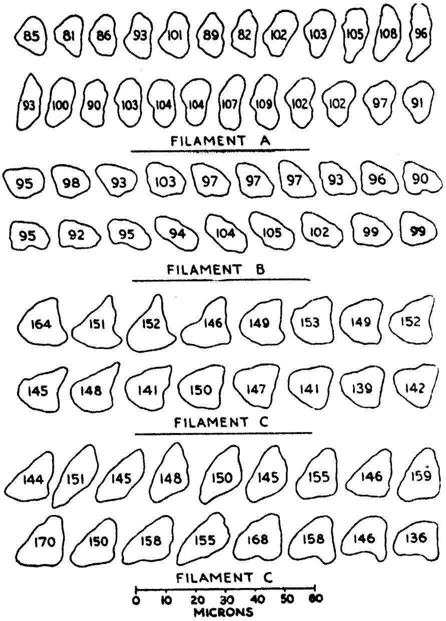

Fig. 1. Series of cross-sections at 20μ intervals.

Experimental

A sample of 13/15 denier high grade Japanese white silk was thoroughly degummed and purified, according to a method previously outlined,[1] and three long filaments, designated as *A*, *B* and *C*, were separated from the purified thread. From each filament a length was cut and wound on a flat glass frame in such a manner that several portions of the length lay parallel and close together. The frames were so constructed that the filaments were under a slight tension, this being necessary to straighten out the natural wavy form of the filament and so ensure true cross-sectioning. The lengths were stained suitably for identification of sections and the three glass frames fixed together with the filaments all parallel, to facilitate the preparation, cutting, and mounting of the sections. Following immersion for three hours in each of 25 per cent., 50 per cent., 70 per cent., 85 per cent., and 95 per cent. alcohol in aqueous solution, and finally 100 per cent. alcohol, the mounted filaments were placed in an 8 per cent. solution of collodion in ether and alcohol, poured to a depth of $1\frac{1}{2}$ cm. in a tall beaker. The beaker was covered with a flat plate and the solvents allowed to evaporate extremely slowly over a period of two weeks; more rapid evaporation was found to produce tiny bubbles along the filaments in the collodion. The solid block was removed from the beaker and cleared in benzene, followed by immersion for four hours in each of 60 per cent. and 25 per cent. solutions of benzene in paraffin oil, pure paraffin oil, solutions of paraffin wax in paraffin oil kept just above their melting points and finally pure paraffin wax (m.p., 52° C.) kept at 54° C. The block was then trimmed and cast in paraffin wax. The preceding elaborate procedure was found necessary to ensure the complete removal of all solvents from the collodion before final casting in wax, since the escape of these into the cast results in a softening of the wax with subsequent failure to obtain true sections, due to displacement of the collodion core in the cast.

Three hundred serial sections of 20μ thickness were cut from the block, each showing a group of filament sections comprising several from each of *A*, *B* and *C*. The group sections were fixed to microscope slides with a trace of albumin, and after removal of the wax by xylene, were mounted in Canada balsam in series of 20 groups per slide. By means of the camera lucida, the contours of the filament sections were drawn upon squared paper and their areas determined graphically.

Results

The information obtained from this work may be summarized briefly as follows:

1. The shape of cross-section of a silk filament varies rapidly along its length. A wide variety of shapes is exhibited over even so short a length as one millimetre, and occasionally re-entrant shapes appear. Typical series of contours at consecutive 20μ intervals are shown in Fig. 1 for the three filaments. A basically triangular configuration may be considered to prevail but with considerable modifications.

2. Although the measurement of apparent diameters under the microscope would indicate very wide variations in the size of the filament, it was found that deviations greater than 20 per cent. of the mean area were rare.

3. The analysis of the data obtained graphically from several hundred contours showed that the variations in cross-sectional area approximate to the normal frequency distribution. In Fig. 2 is shown the result for filament *B*, similar results being obtained for *A* and *C*, although the three filaments differed considerably in mean size.

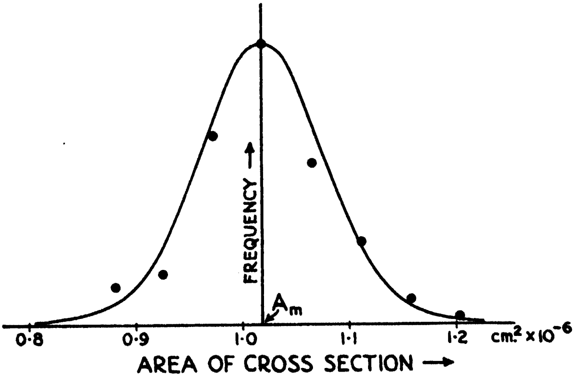

Fig. 2. Comparison of observations and normal frequency distribution.

THE EFFECT OF VARIATIONS UPON EXTENSIBILITY

The load-extension relationship of a material is most simply and usefully expressed in terms of stress (s=force per unit area) and strain (e=extension per unit initial length). This expression is easily obtained in the case of a uniform filament of material supporting a load, since the stress throughout such a filament is constant. In an irregular filament under load, however, the stress is not constant over its length, but varies in a manner dependent upon the variations in the cross-sectional area of the filament. Although the curvature of the cross-sectional periphery will also have an effect upon these variations in stress, this is sufficiently small to be neglected for the purposes of the present discussion.

The nature and magnitude of the irregularities of area and shape of cross-section in the silk filament have been seen in the preceding section. To correlate and interpret correctly the experimental load-extension data obtained from many filaments which differ considerably in size, the extent to which these irregularities may influence filament behaviour must be considered. The treatment of this problem with substances of normal elastic behaviour is exceedingly complicated, but for silk it may be very much simplified by a consideration of the load-extension curve typically obtained in experiment. Examples of this curve are seen in Fig. 3, and it will be observed that the curves consist of two approximately linear portions joined by a region of curvature.

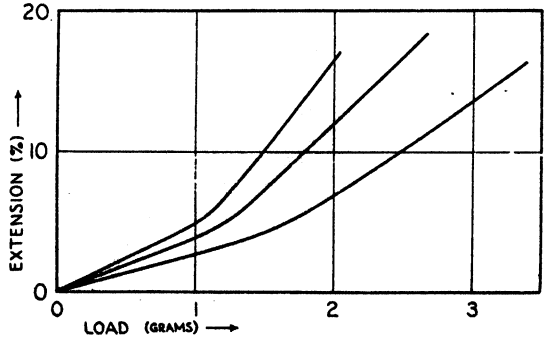

Fig. 3

If an ideally uniform filament of any material were to display a load-extension relation consisting only of two linear segments meeting at some critical load value, then it follows that an irregular filament would display a similar relation with the introduction of a curved region over a range including the critical point. The curves obtained with silk suggest that uniform silk filaments would conform approximately to the relation shown in Fig. 4, so that the assumption of this ideal relation affords a logical basis for the mathematical investigation of the influence of irregularity upon the behaviour of the silk filament. The problem may be treated in two sections, (1) stress less than S_2 throughout the filament, (2) stress greater than S_2 in some or all parts of the filament.*

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* See Addendum.

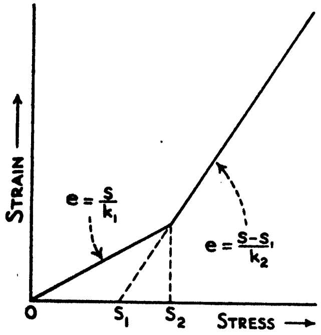

Fig. 4.

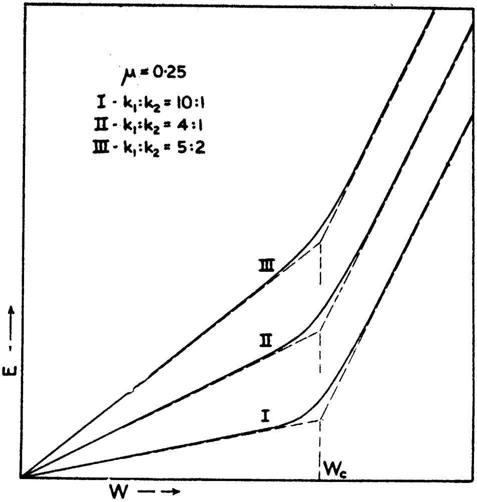

Fig. 5

(1) Any filament supporting a load W, such that nowhere in the filament is the stress greater than S_2, extends according to the law $e = \frac{s}{k_1}$, and the extension of the filament is given by

$$E = \frac{W}{k_1}\int_0^L \frac{dx}{A(x)} \quad \text{..........(1)}$$

where L = the length of the filament,

$A(x)$ = the area of cross-section at a point associated with the length parameter x,

and k_1 = a constant, which in the case of a truly elastic material is Young's Modulus.

If now there are compared two filaments of the same mean area of cross-section A_m, one of which is uniform and the other irregular, the ratio of the extensions for a given load will be:

$$\frac{E_{irreg}}{E_u} = \frac{1}{L^2}\int_0^L \frac{dx}{A(x)}\int_0^L A(x)dx \quad \text{..........(2)}$$

$$\text{since by definition } A_m = \frac{1}{L}\int_0^L A(x)dx$$

The expression (2) can be shown to have the value $1+a$ where a is positive and depends upon the variations in $A(x)$. The value of a may be obtained with sufficient accuracy by means of the trapezoidal rule or Simpson's rule if there is provided a set of observed values of $A(x)$ for any given filament in question. In the case of the white Japanese silk examined for variations in cross-sectional area, it has been shown that these variations follow approximately the normal frequency distribution. Assuming this distribution, we may let the observed extreme values of $A(x)$ be represented by $A_m(1 \pm \mu)$ such that the frequency of these extremes is 1/100 that of the mean A_m.

The expression (2) then takes the following values dependent upon μ:

μ	$\frac{1}{L^2}\int_0^L \frac{dx}{A(x)}\int_0^L A(x)dx$	a
0·10	1·0010	0·0010
0·20	1·0044	0·0044
0·30	1·0101	0·0101
0·40	1·0183	0·0183
0·50	1·0295	0·0295

It is clear therefore that variations following the normal frequency distribution may be considerable without appreciably changing the behaviour from that of a uniform filament. For the three filaments of Japanese silk already referred to, the values obtained for μ were 0·27, 0·18, and 0·21, so that the ratios of the extension of these filaments to that of corresponding uniform filaments would be 1·008, 1·004 and 1·005, respectively.

(2) When the load is sufficiently great to produce stress greater than S_2 in the cross-section of minimum area, the extension of part or all of the filament follows the law

$$e = \frac{s - s_1}{k_2} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

Considering this part of the filament, its deviation from the law $e = \frac{s}{k_1}$ is expressed by

$$\delta e = \frac{s - s_1}{k_2} - \frac{s}{k_1} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (4)$$

Let the fraction $f_\nu d\nu$ of the length of the filament be associated with areas of cross-section in the range $A_m(1+\nu)$ to $A_m(1+\nu+d\nu)$. The stress in this fraction, due to a load W, is

$$s = \frac{W}{A_m(1+\nu)} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (5a)$$

Since $\frac{s_2 - s_1}{k_2} = \frac{s_2}{k_1}$, and writing $W_c = A_m s_2$, then $s_1 = \left(1 - \frac{k_2}{k_1}\right)\frac{W_c}{A_m}$, (5b)

If the fraction $f_\nu d\nu$ is subject to (3), we may substitute in (4) for s and s_1 from (5a) and (5b), so that

$$\delta e = \frac{1}{A_m}\left(\frac{1}{k_2} - \frac{1}{k_1}\right)\left(\frac{W}{1+\nu} - W_c\right).$$

This is to be applied to all parts of the filament for which $s > s_2$, or $\frac{W}{A_m(1+\nu)} > s_2$, or $\nu < \frac{W}{W_c} - 1$. The additional contribution to the extension of the filament due to the fraction $f_\nu d\nu$ may now be written

$$f_\nu\, d\nu.\, L.\, \delta e.$$

Integrating this expression for all values of $\nu < \frac{W}{W_c} - 1$, the deviation of the total extension of the filament from the law $e = \frac{s}{k_1}$ is obtained, which, when added to (1) gives the extension of the filament for all values of W:

$$E = \frac{W}{k_1}\int_0^L \frac{dx}{A(x)} + \frac{L}{A_m}\left(\frac{1}{k_2} - \frac{1}{k_1}\right)\int_{\nu=-\mu}^{\nu=\frac{W}{W_c}-1}\left(\frac{W}{1+} - W_c\right) f_\nu\, d\nu \ldots (6)$$

The lower limit $\nu = -\mu$ is assigned since the contribution from still smaller values of ν is negligible.

Since the frequency distribution of cross-sectional area defined by f_ν has been found to be approximately normal, f_ν may be taken as $\frac{h}{\sqrt{\pi}} e^{-h^2\nu^2}$. The above expression (6) may then be evaluated, if suitable values are given to the constants k_1, k_2 and W_c, and the substitution

$$f_\nu = \frac{1}{\mu}\sqrt{\frac{4{\cdot}60}{\pi}}\, e^{-\frac{4{\cdot}60}{\mu^2}\nu^2} = \frac{1{\cdot}21}{\mu} e^{-\frac{4{\cdot}60}{\mu^2}\nu^2}$$

is made, in accordance with our previous definition of μ. Selecting the value $\mu = 0{\cdot}25$ as representative of the filaments examined, and taking arbitrary units of length and load such that $k_1 = 1$ and $W_c = 1$, then for silk in ordinary circumstances $k_2 = \frac{1}{4}$ approximately, and $f_\nu = 4{\cdot}84 e^{-73{\cdot}6\nu^2}$. The extension introduced into the filament by a load W is then given by

$$E = \left\{ 1{\cdot}007W + 14{\cdot}5 \int_{\nu = -0{\cdot}25}^{\nu = W-1} \left(\frac{W}{1+\nu} - 1 \right) e^{-73{\cdot}6\nu^2}\, d\nu \right\} L$$

Graphical integration of this and similar expressions for other values of k_2 yields the curves shown in Fig. 5, compared with the ideal relation consisting of two straight lines defined in each case by the constants k_1 and k_2. Only while W is increasing from the greatest value at which all of the filament obeys $e = \frac{s}{k_1}$ to the least value at which all of the filament obeys $e = \frac{s - s_1}{k_2}$ does the calculated curve depart appreciably from the ideal relation. It will be seen that this departure and the range of W over which it occurs are small. Thus, in general, the observed extension does not differ seriously from that which would be found in a uniform filament of the same mean area of cross-section, so that for purposes of correlation, silk filaments may be regarded as uniform, and the correlation established upon the basis of stress only, as calculated from observed values of A_m. It also follows that the true stress-strain relationship for the material of a silk filament must be represented closely by two linear portions meeting at a point.

DETERMINATION OF THE MEAN AREA OF CROSS-SECTION OF A SILK FILAMENT

The preparation of serial cross-sections of a filament provides information on the variations in cross-sectional area but does not give an absolute value for the mean which can be associated with any precisely known condition. Even if this were not the case, the time involved in serial sectioning would render this procedure impractical as a method for the determination of mean area of cross-section for a large number of filaments. Three procedures were investigated as possible methods for the determination of the mean area of cross-section of a filament, and although the first of these proved unsatisfactory, the results are recorded because of the extensive and successful use of the method on other filaments including certain textile fibres.

Twelve consecutive segments of 10 cm. length were cut from each of the three filaments A, B and C, selected in the preparation of serial sections. Three groups of twelve segments each were then formed by selecting every third segment of each filament: for example, the first group comprised the segments 1, 4, 7, and 10 from each of A, B and C. One group was employed for each of the three methods investigated for determining mean area of cross-section, thus permitting a comparison for each filament of the average values obtained.

Method 1.—Microscopic Measurement of Apparent Diameter.

Microscopic measurement of diameter is a simple and convenient method for determining area of cross-section of fibres approximately circular in contour. For example, in the case of wool fibres it is widely and successfully employed. With silk, however, it has been shown that wide variations occur in shape of cross-section. To discover whether or not any relation exists between a set of observed apparent diameters and the area of cross-section, representative contours which were reproduced by the camera lucida, and whose areas were known, were selected for further study. Apparent diameters as viewed from six equally spaced directions in the plane of section were then measured and averaged, the directions being chosen without reference to the contour in any particular. Some of the results are shown in Table I.

Table I

Area A	Mean Apparent Diameter D_m	Mean Deviation D_v	Diameter of Equivalent Circle $D_c = 2\sqrt{\frac{A}{\pi}}$	$\frac{D_c^2}{D_m^2}$
7·05	3·33	0·57	2·99	0·805
5·50	2·86	0·13	2·65	0·859
4·98	2·73	0·33	2·52	0·851
7·66	3·58	0·57	3·12	0·760
4·78	2·80	0·16	2·47	0·778
5·41	2·86	0·74	2·63	0·845
7·74	3·36	0·33	3·14	0·873
6·95	3·38	0·54	2·98	0·777
7·15	3·08	0·39	3·02	0·961
6·29	3·19	0·43	2·83	0·787
			MEAN :	0·83

The observed quantities D_m and D_v display no relation to the true area A. It can readily be seen that an infinite number of shapes differing in area may yield the same set of apparent diameters. This fact precludes precise application of this method to individual segments of a filament unless a great many observations are made, in which case it is possible to deduce the mean area A_m with some degree of reliability. Denham and Hutton[2] have shown that a mean factor K can be found such that for a given type of silk $A_m = K\frac{\pi D^2}{4}$, and point out that the number of measurements of D necessary to obtain a representative mean value is large and depends upon the character of the sample. It is of interest to observe that the value of K deduced by the above authors for white Japanese silk is in agreement with that obtained in the present study.

The measurement of apparent diameter at 30 points along the length of each of the four segments from filaments A, B and C yielded values for their areas of cross-section in the ratios 1·00 : 0·96 : 1·64, respectively. It will be seen that the values of these ratios differ considerably from those obtained by more reliable methods.

Method 2.—Determination of Filament Weight

If the weight, density and length of a filament are known, the mean area of cross-section can readily be calculated. Data for the density of silk has been determined by the authors.[1] The accurate measurement of length presents no difficulty. The determination of the mean area of cross-section therefore reduces to the weighing of the filament with a sufficiently high degree of accuracy. For this purpose a micro-balance of standard design was constructed.

The balance is of the horizontal torsion filament type using a quartz filament 15 cm. long and 0·0021 cm. in diameter. This filament is carried by a brass yoke and supports a cross-beam of fine glass tubing, the weighing arm of which is 10 cm. long and forms a hook at the end to receive the silk samples. The cross-beam is suitably counterpoised, and a small plane mirror is attached to it at right-angles directly beneath the torsion filament. To counterpoise the mirror and obtain the required sensitivity, a short length of 36-gauge copper wire was projected vertically above it and by cutting segments from this wire the centre of gravity of the whole assembly was brought to the correct position. The balance is housed in a glass case fitted with a beam rest and a sliding mechanism designed to remove and replace silk filaments on the beam without opening the case, the filaments being coiled previously into an open loop for weighing. A curved metre scale, observed by reflection in the mirror with a short range telescope, is used to read off the angle of deflection of the beam. The whole apparatus was set up permanently in a room in which humidity and temperature are controlled. It has been found that the presence of lamps within a few feet of the balance produces sufficient convection currents within the case to render the balance inaccurate; but with proper precautions and thermal shielding this difficulty may be obviated, the balance beam comes to rest quickly and shows only a slight zero drift. A small shielded 15-watt lamp is used to illuminate the balance and scale only when necessary for loading or observation. The calibration of the balance was carried out in the following manner. A length of 75 denier 48 filament rayon yarn was conditioned in the balance room at 65 per cent. relative humidity and 70° F., and from this a 10 cm. length was cut and weighed on a phosphor bronze torsion balance specially calibrated with small platinum wire weights. The individual filaments of the yarn were then weighed on the quartz micro-balance and the sum of the observed deflections equated to the known weight of the 10 cm. length of yarn. The balance constant thus found was $3{\cdot}52 \pm 0{\cdot}03 \times 10^{-7}$ g. per cm. deflection. Under the conditions of use only a small error is introduced by the assumption of proportionality between deflection and true weight, since the angle at which the balance beam becomes inclined to the horizontal is rarely greater than 5°.

One group of 12 segments taken from the three filaments A, B and C were weighed on the micro-balance. The weights observed are given below, together with the corresponding mean areas of cross-section at 65 per cent. relative humidity, taking the value for density as 1·352 g. per c.c.

	A		B		C	
	Weight g. × 10^{-6}	A_m cm.^{2} × 10^{-6}	Weight g. × 10^{-6}	A_m cm.^{2} × 10^{-6}	Weight g. × 10^{-6}	A_m cm.^{2} × 10^{-6}
	12·4	0·92	13·2	0·98	21·3	1·58
	12·0	0·89	12·5	0·92	21·7	1·61
	11·8	0·87	13·0	0·96	21·0	1·55
	12·2	0·90	13·1	0·97	20·5	1·52
Mean values ...	12·10	0·89	12·95	0·96	21·13	1·56
Ratios of A_m ...	—	1·00	—	1·08	—	1·75

It should be noted that although mean values have been taken from the above figures for comparison with mean values obtained by other methods, the variation in weight observed between different segments of the same filament is real. Variations in weight amounting to several per cent. of the mean have been found in later work to exist along the natural filament ; and for this reason it is desirable to obtain a measure of A_m for every segment used in experiment rather than to assume the same mean value to hold for different segments of the same filament. The method of weighing permits rapid and accurate determination of the mean area of cross-section for such individual segments with little danger of injury, and further admits of close control of the condition of the silk. Given a knowledge of the lateral swelling of the silk filament, the mean area of cross-section corresponding to any conditions of relative humidity can be calculated from the value obtained at some known condition.

Method 3.—Comparison by Extensibility

If the differences in the load-extension relationship of silk filaments tested under similar conditions arise solely from inequalities in their average size, then these differences should lead to a close estimate of the ratios of the mean areas of cross-section. It is to be pointed out that in experiment the rate of loading is controlled while theory requires a constant rate of increase of stress. The estimate cannot be exact, therefore, but a suitable rate of loading can be chosen to minimise this error. It will also be recognized that any method using extensibility data gives comparative and not absolute values for the sizes of the filaments, and further is destructive of the particular lengths subjected to test.

Segments of each of the three filaments *A*, *B* and *C*, comprising one group, were subjected to constant rate of loading in an extensometer designed for use with single filaments and fitted with a frictionless electric-spark autographic recorder. The four segments of each filament tested yielded load-extension curves in good agreement. By a suitable choice of a stress factor in each case, the curves for the different filaments were brought into coincidence. The chosen factors must then be in the inverse ratios of the mean areas of cross-section of the corresponding filaments. The values of the ratios so obtained for the filaments *A*, *B* and *C* were 1·00 : 1·07 : 1·75, respectively. These results will be seen to be in excellent agreement with those obtained by the method of weighing, and therefore give experimental corroboration of the validity of the deduction that filaments may be compared on a basis of stress calculated on the mean area of cross-section.

Since the investigation described was carried out, more than 150 filaments 10 cm. long have been weighed and used in experiments on the extensible properties of silk. The mean cross-sectional areas of these filaments have been found to lie scattered over the range $0{\cdot}60 \times 10^{-6}$ to $1{\cdot}32 \times 10^{-6}$ cm.^{2}. The behaviour of these filaments under load may be correlated with complete satisfaction on the basis of calculated stress and forms the material for a later paper.

REFERENCES

[1] Goodings and Turl. *J. Text. Inst.*, 1940, **31**, T.69.

[2] Denham and Hutton. *J. Text. Inst.*, 1935, **26**, T.111.

The authors wish to acknowledge the helpful criticism and advice given by Dr. J. N. Goodier on the mathematical treatment of irregular filaments.

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ADDENDUM*

The theoretical discussion given in the paper will appear somewhat obscure to the general reader and the following notes are appended with a view to amplifying the mathematical treatment of the subject and thus assisting in a fuller comprehension of what is an important consideration in the physical properties of silk filaments.

For a thread of non-uniform cross-section A, the stress at any element of thickness Δx is $W/A(x)$ where $A(x)$ is the cross-sectional area of that particular element and varies along the length of the thread.

For the given element, strain $\Delta e = W/k_1 A(x)$
and extension $\Delta E = W \ \Delta x / k_1 A(x)$

Thus, total extension E for length of filament L

$$= \int_0^L \frac{W dx}{k_1 A(x)} = \frac{W}{k_1} \int_0^L \frac{dx}{A(x)}$$

For a filament of uniform cross-sectional area A_m, the total extension E_u is immediately given by

$$E_u = \frac{W}{k_1 A_m} \cdot L$$

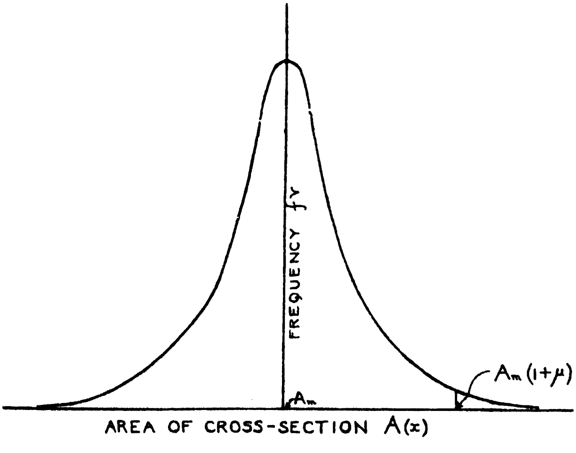
assuming Hooke's Law to be obeyed.

Hence, if E_{irreg} is the total extension of an irregular filament of mean cross-sectional area equal to A_m, then

$$\frac{E_{irreg}}{E_u} = \frac{W}{k_1} \cdot \frac{k_1 A_m}{WL} \int_0^L \frac{dx}{A(x)} = \frac{A_m}{L} \int_0^L \frac{dx}{A(x)}$$

$$\text{but } A_m = \frac{1}{L} \int_0^L A(x) dx$$

$$\therefore \frac{E_{irreg}}{E_u} = \frac{1}{L^2} \int_0^L \frac{dx}{A(x)} \int_0^L A(x) dx$$



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* This amplification of the mathematical treatment was proposed by one of the referees and the authors agreed that it should be printed with the paper. *Editor.*

Significance of μ

Write $A(x) = A_m(1+\nu)$, then $f\nu = \frac{h}{\sqrt{\pi}} e^{-h^2\nu^2}$

When $A(x) = A_m$, then $\nu = 0$ and $f\nu = \frac{h}{\sqrt{\pi}}$

When $A(x) = A_m(1+\mu)$, then $\nu = \mu$ and $f'\nu = \frac{h}{\sqrt{\pi}} e^{-h^2\mu^2}$

$$\text{By definition, } \mu \text{ is such that } \frac{f'\nu}{f\nu} = 0{\cdot}01$$

$$\text{Hence } e^{-h^2\mu^2} = 0{\cdot}01$$

$$\text{whence } -h^2\mu^2 = 4{\cdot}60$$

$$\text{and } h = \frac{\sqrt{4{\cdot}60}}{\mu}$$

$$\text{Thus } f\nu = \frac{1}{\mu}\,\frac{\sqrt{4{\cdot}60}}{\pi}\, e^{\frac{-4{\cdot}60\,\nu^2}{\mu^2}}$$

For each arbitrary value of μ chosen, we shall obtain a definite frequency curve. Thus if $\mu = 0{\cdot}1$,

$$f\nu = \frac{1}{0{\cdot}1}\sqrt{\frac{4{\cdot}60}{\pi}}\, e^{-460\nu^2} = 12{\cdot}1\, e^{-460\nu^2}$$

Evaluation of $\frac{1}{L^2}\int_0^L \frac{dx}{A(x)} \int_0^L A(x)dx$

We have the fraction of the total number of sections with areas lying between $A_m(1+\nu)$ and $A_m(1+\nu+d\nu)$ is $f\nu d\nu$. Since these sections are of equal length, 20μ, this is also the fraction of the total length L. Hence actual length of filament, dx, with areas between $A_m(1+\nu)$ and $A_m(1+\nu+d\nu)$ $= Lf\nu d\nu$.

Thus $A(x) = A_m(1+\nu)$
and $dx \;= Lf\nu d\nu$

$$\text{Hence } \int_0^L A(x)dx = \int_{-\mu}^{+\mu} A_m(1+\nu)Lf\nu d\nu$$

$$\text{Similarly } \int_0^L \frac{dx}{A(x)} = \int_{-\mu}^{+\mu} \frac{f\nu L}{A_m(1+\nu)} d\nu$$

$$\text{Thus } \frac{1}{L^2}\int_0^L \frac{dx}{A(x)} \int_0^L A(x)dx = \int_{-\mu}^{+\mu} (1+\nu) f\nu\, d\nu \int_{-\mu}^{+\mu} \frac{f\nu}{1+\nu} d\nu$$

Substituting the appropriate value of μ in $f\nu = \frac{1}{\mu}\sqrt{\frac{4{\cdot}60}{\pi}}\, e^{\frac{-4{\cdot}60}{\mu^2}}$ we can plot the functions $(1+\nu)\,f\nu$ and $f\nu/(1+\nu)$ and thus evaluate the integrals by Simpson's Rule.

The authors evaluate these integrals by Simpson's Rule and thus show that E_{irreg}/E_u does not deviate much from unity even when μ is large.

THE JOURNAL OF THE
TEXTILE INSTITUTE
TRANSACTIONS

12—ON THE HEAT TRANSMISSION OF TEXTILE FABRICS

PART II

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Abstract

The work described in a previous communication was continued with a view to comparing the heat transmission through fabrics worn by women indoors with the heat transmission of those worn by men. The results show that women can be just as warmly clothed on the body as men without wearing unusual clothing, but that on the calf of the leg a man's clothing has a T.I.V. about twenty times that of a woman. The results are discussed from the point of view of the heating engineer.

In a previous communication[1] a description was given of an apparatus for measuring the heat transmission of fabrics and some results on the fabrics worn by men indoors were given. One of the main objects of undertaking this investigation was to obtain data which would be of use in connection with comfort temperatures. The most important conclusion reached was that the effect of warm clothing was far more noticeable when air was moving than when it was still. Thus in still air a warmly clad man might not be particularly uncomfortable in conditions which suit a lightly clad man, while if a draught is admitted which the warmly clad man would scarcely notice, the lightly clad man would be extremely uncomfortable. It is not merely because human beings are more sensitive to atmospheres which are a little too cold than to those which are a little too warm: the clothing which they may be wearing changes in thermal insulating value when the air movement changes.

This fact emphasized the desirability of completing the survey of typical fabrics worn indoors by including those worn by women. The general opinion among people is that men are very much more warmly clad than women; but as men do not wear women's clothes nor do women wear men's clothes under normal conditions, the general opinion may be far more of an assumption than most of us realize. An apparatus, which is inanimate, can decide whether women are really very much more lightly clad than men and can also inform us what combinations of fabrics worn by women give similar thermal insulating values to combinations of entirely different fabrics worn by men; and in point of fact we reach the very interesting conclusion that without wearing unusual clothing a woman can be actually more warmly clad than a man on the body.

Samples Selected

The fabrics used in the tests consisted of the following:—

1. A piece of an elastic girdle expanded to one-and-a-half times its normal length.
2. A piece of artificial silk commonly used for a slip.
3. A piece of wool underwear.
4. A piece of jersey material cut from a small child's sweater.
5. A piece of flannel used for dresses.
6. A piece of cotton print used for dresses.
7. Two pieces of "silk" used for dresses—one weighted real silk, the other artificial silk.
8. A piece of a thick silk stocking.
9. A piece of a thin silk stocking.

The thicknesses and weights of these materials are given in Table I.

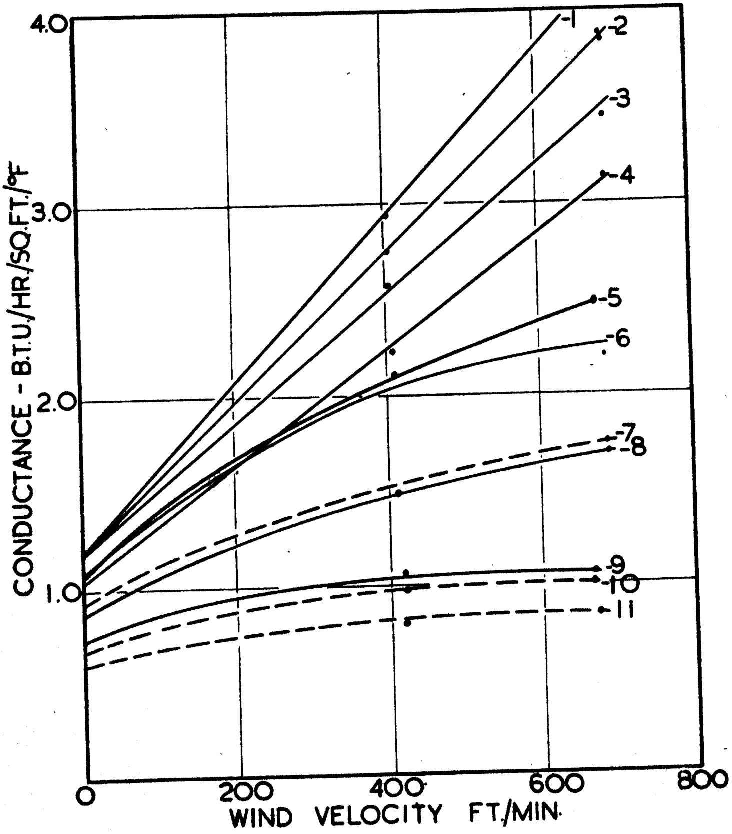

Fig. 1 (*a*)

1. Uncovered cylinder: also thin silk stocking.
2. Weighted silk: also thick silk stocking.
3. Acetate rayon.
4. Cotton print.
5. Flannel.
6. Girdle (expanded 1½ times normal length).
7. Serge + suit lining + shirting.
8. Jersey.
9. Acetate rayon over ½" rings.
10. Serge over ½" rings.
11. Serge + suit lining + shirting over ½" rings.

Results of Tests

Some of the materials were tested alone, but the most interesting results were obtained from tests in which dress materials were combined with some of the other samples. The girdle for instance was combined with the four kinds of dress materials: the results of this group of tests are shown diagrammatically in Figs. 2 (*a*) and (*b*), (*a*) referring to conductance values and (*b*) to T.I.V.'s* The results on another group of tests in which the dress materials were combined with the girdle and white wool underwear are shown in Figs. 3 (*a*) and (*b*), and results with a third group of tests in which the dress materials were combined with the girdle and silk slip material are shown in Figs. 4 (*a*) and (*b*). Results on some of the materials measured

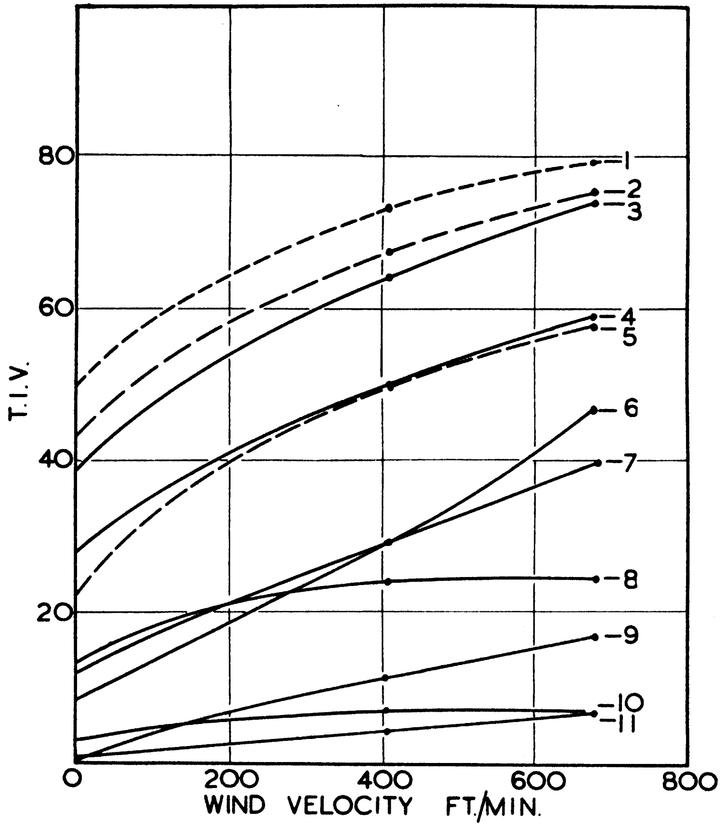

Fig. 1 (*b*)

1. Serge + suit lining + shirting over ¼″ rings.
2. Serge over ¼″ rings.
3. Acetate rayon over ¼″ rings.
4. Jersey.
5. Serge + suit lining + shirting.
6. Girdle (expanded 1½ times normal length).
7. Flannel.
8. Cotton print.
9. Acetate rayon.
10. Thick silk stocking.
11. Weighted silk.

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* T.I.V. or thermal insulating value is defined as

$$\left(1-\frac{\text{heat loss from covered cylinder}}{\text{heat loss from uncovered cylinder}}\right)100$$

alone and the results on some materials held out over ¼ inch celluloid rings are shown in Figs. 1 (*a*) and (*b*). The broken lines on the diagrams refer to fabrics or combinations of fabrics worn by men. It can easily be seen that the thermal insulation afforded by a knitted jersey material along with wool underwear and a girdle is as great or even greater than the insulation afforded by a tweed suiting with lining along with wool underwear and shirting.

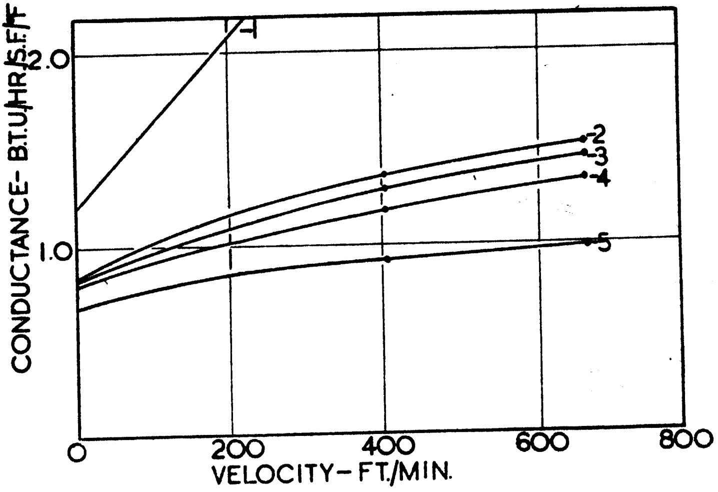

Fig. 2 (*a*)

1. Uncovered cylinder.
2. Girdle + wool underwear + weighted silk.
3. „ „ „ + cotton print.
4. „ „ „ + flannel.
5. „ „ „ + jersey.

While these comparisons are simple on an apparatus, the application of the results to clothing worn on the body is not straightforward. The body is not evenly covered by garments as an apparatus is by samples of cloth, and furthermore air pockets are formed which on the one hand provide insulation but on the other hand are liable to introduce a sort of bellows effect when an individual is moving and thus cool the body. One must be careful therefore in concluding that because the broken line of Fig. 3 (*b*), for instance, which relates to a man clothed in a lined serge jacket over a shirt, lies below the line relating to a woman wearing a jersey material over a girdle, that therefore the woman is more warmly clothed than the man.

The style of clothing comes into the matter and is indeed a very important factor. For instance, a man wearing a serge jacket over a shirt may not be covered over the chest with anything but the shirt. Yet if the shirt happens to be loose over the skin he may have as much protection as he has where the serge jacket is tight. The importance of these air spaces is seen in Figs. 1 (*a*) and (*b*). Even a piece of thin Celanese held out from the apparatus a quarter of an inch was found to be almost as efficient a heat insulator as a piece of tweed suiting with lining over shirting and wool underwear if these were close to the apparatus. Soft materials like Celanese lie close to the body as a rule and therefore the possibility of improving their thermal insulating value in this way is of course remote in practice, even if fashion did not favour snug fitting garments for women. The results, however, do indicate—if they do not prove conclusively—that a man need not be more heavily clothed on the body than a woman wearing a jersey material. The results show, too, that silk is not more efficient than cotton in so far as thermal insulation value is concerned. Silk has a tendency to lie close to the body and when this occurs one can see from Figs. 1 (*a*) and (*b*) that its value as thermal insulation on the body is very small indeed. There is not a great advantage in wearing flannel instead of a cotton, although the data do show that the flannel is definitely the warmer; but the jersey material appears to be very much warmer than the flannel. It is worth noting that the jersey material shows up to advantage particularly in still air.

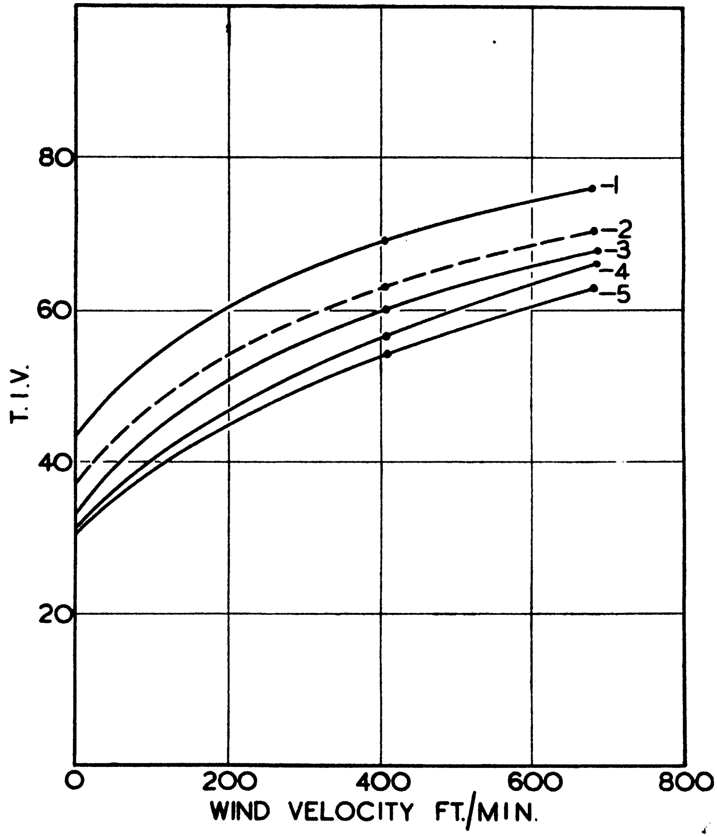

Fig. 2 (*b*)

1. Girdle + wool underwear + jersey.
2. Wool underwear + shirting + suit lining + tweed sewn on loosely.
3. Girdle + wool underwear + flannel.
4. ,, ,, ,, + cotton print.
5. ,, ,, ,, + weighted silk.

While the comparison of clothing on a man's body with that on a woman's is complicated by the difference in styles, the comparison of the clothing on the lower part of the leg is more simple. The insulation on the lower part of the leg is rather an important matter under those heating conditions which produce large temperature gradients. Draughts, windows open at the bottom instead of at the top, and zero weather on the outside of a single glazed window are all contributing factors to the formation of temperature gradients and while a discussion of these factors is outside the scope of this communication, they are mentioned because the lower part of the leg is often in an atmosphere two to four degrees colder than the head. To offset this notoriously uncomfortable condition the lower part of the leg should be well insulated against cold. Our results on silk stockings show that they afford practically no thermal insulation at all. The conductances of the thin sample differed so little from the values obtained for the uncovered body that the differences compared with the experimental error and rendered the T.I.V. calculations unreliable. The sample of thick silk stocking did show a measurable T.I.V., but this was about 2/43 of the T.I.V. found for a piece of serge held out from the apparatus on the ¼-inch celluloid rings; this is the test which would appear to correspond most closely to the clothing worn by men on the lower part of the leg. On the ankle of course the T.I.V. of a man's clothing is much lower than the T.I.V. of serge held out from the body.

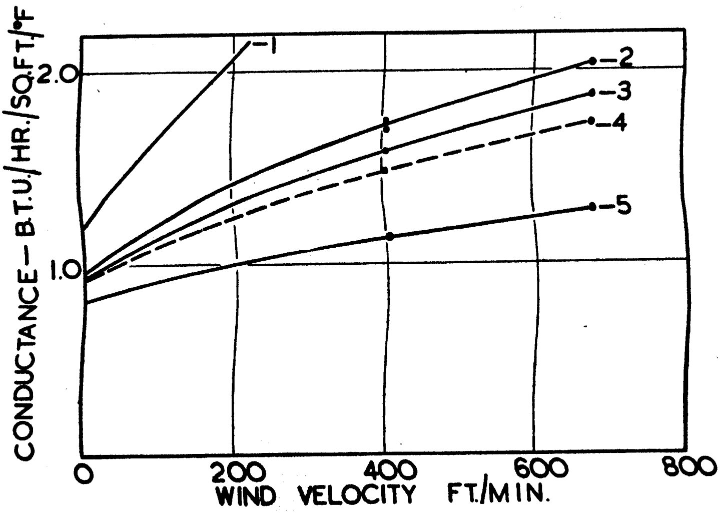

Fig. 3 (*a*)

1. Uncovered cylinder.
2. Girdle + weighted silk: also girdle + cotton print.
3. Girdle + flannel.
4. Shirting + suit lining + serge.
5. Girdle + jersey.

The figures obtained from the various measurements are given in Tables II and III. A slight difference has been made in calculating the T.I.V.'s in this communication from the last. Instead of measuring the wind velocity on each occasion a mean value of a number of measurements of wind velocity was taken for two settings of the current driving the fan. The corresponding wind velocities were termed moderate and strong. The actual mean value for the "moderate" velocity was 405 feet per minute and for the "strong" velocity 677. The conductance from the uncovered apparatus at these velocities was taken to be 2·95 and 4·12 respectively: these figures were obtained from the graph shown in Figs. 1, 2 and 3 of the previous communication. The T.I.V.'s at "moderate" and "strong" velocities were simply

$$100\left(1-\frac{C_m}{2.95}\right) \text{ and } 100\left(1-\frac{C_s}{4{\cdot}12}\right)$$

respectively where C_m and C_s were the conductances of a particular sample in the moderate and strong air current.

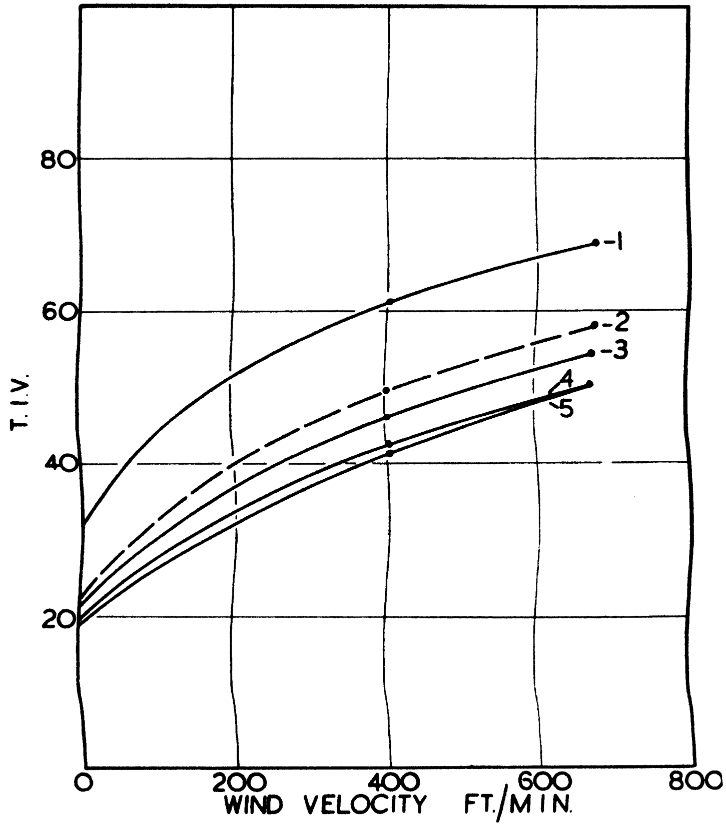

Fig. 3 (*b*)

1. Girdle + jersey.
2. Shirting + suit lining + serge.
3. Girdle + flannel.
4. Girdle + cotton print.
5. Girdle + weighted silk.

General Conclusions

When this work was first undertaken, it was criticized on the ground that no matter what results were found, people would still wear the clothing which fashion decreed. But the value of such data does not consist in constituting a basis for a campaign against conventional clothing but rather to give those who have the responsibility of heating buildings an idea of what complaints to expect from those who are conventionally dressed and to enable them to distinguish between justifiable complaints and unjustifiable ones. If we could place our thermostats at the level of the body and ignore all complaints if the room felt too hot or too cold provided this thermostat was operating as desired, then there would be no justification for the complaint that women were more lightly clothed than men. Any such complaint should be replied to by the individual himself or herself by wearing suitable clothing. But the heating engineer's problem is not so simple. One reason that women demand a higher temperature indoors than men is apparently because the lower part of the leg is not protected. Thus women have a genuine reason for requiring higher temperatures than men, and the great problem at the present day in heating buildings for conventionally dressed men and women is the elimination of temperature gradients. While everyone knows that conventionally dressed women are sensitive to cold on the lower part of the legs few people probably realize that the thermal insulating value of the clothing on the calf of a man's leg is more than 20 times as great as that of the stocking on the woman's leg.

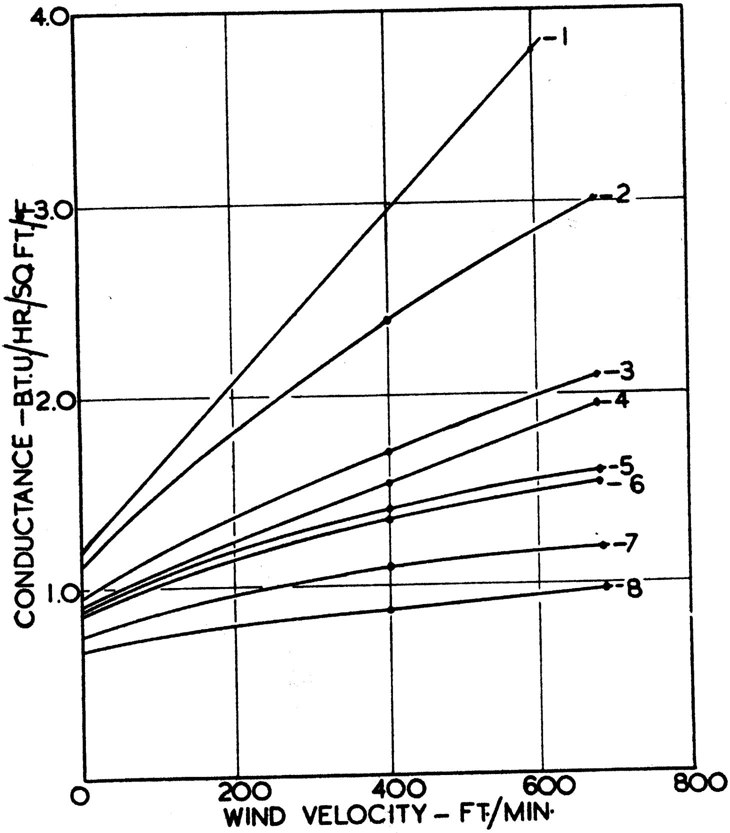

Fig. 4 (*a*)

1. Uncovered cylinder.
2. Silk slip + weighted silk
3. Girdle + silk slip + weighted silk.
4. „ „ „ + cotton print.
5. Girdle + silk slip + flannel.
6. Silk slip + jersey.
7. Girdle + silk slip + jersey.
8. Silk slip + weighted silk over ½" rings.

The surprising thing is that women do not demand even higher temperatures relative to what men require and the explanation may be that the calf of the leg is fairly insensitive to cold. Nevertheless, in view of the results given above, there can be little possibility of improving the atmospheric conditions indoors so that the air may be fresh and cool to breathe unless heating engineers devise some method to keep the temperatures near the floor actually warmer than those at the level of the body. With any method of heating which heats the air, convection currents render this almost a physical impossibility but by the use of radiant heat the problem does not seem entirely insoluble.

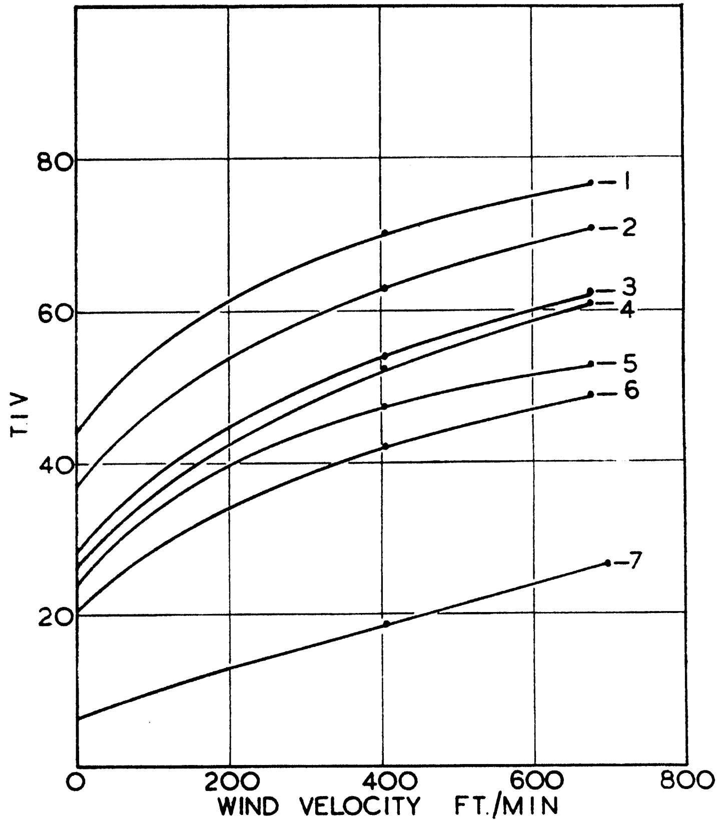

Fig. 4 (*b*)

1. Silk slip + weighted silk over ¼″ rings.
2. Girdle + silk slip + jersey.
3. Silk slip + jersey.
4. Girdle + silk slip + flannel.
5. Girdle + silk slip + cotton print.
6. ,, ,, ,, + weighted silk.
7. Silk slip + weighted silk.

The author's thanks are due to Mr. C. H. Bayley of the Division of Chemistry, National Research Laboratories, Ottawa, and to Miss A. S. Tweedie, until recently of that division, for their advice in the selection of typical samples and for their assistance in obtaining them.

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Table I

Material	Thickness $\left(\frac{\text{mm.}}{100}\right)$	Weight oz./sq. yd.
Weighted silk	19	2·82
Acetate rayon	35	5·19
Cotton print	18	3·01
Flannel	47	3·99
Jersey	103	6·63
Silk Slip (viscose rayon)	15	2·29
Wool Underwear	100	6·15
Girdle (not expanded)	193	21·07
Thick Silk Stocking	31	2·93
Thin Silk Stocking	11	0·59
Serge	68	9·26

Table II

Description of Test	Conductance			T.I.V.		
	Still Air	Moderate Air Movement	Strong Air Movement	Still Air	Moderate Air Movement	Strong Air Movement
Acetate rayon, fairly tight	1·19	2·61	3·42	0·5	11·4	16·9
Weighted silk, ,, ,,	1·19	2·76	3·83	0·9	4·4	7·0
Cotton print, ,, ,,	1·04	2·23	3·10	13·2	24·4	24·7
Flannel, ,, ,,	1·06	2·09	2·49	11·8	29·3	39·6
Jersey material, ,, ,,	0·87	1·47	1·69	27·6	50·1	59·1
Acetate Rayon over ¼" rings	0·74	1·06	1·06	38·7	64·1	74·2
Girdle-expanded 1½ normal	1·10	2·09	2·19	8·1	29·1	46·8
Silk Stocking, thick ...	1·16	2·74	3·81	3·2	7·1	7·5
Silk Stocking, thin ...	1.21	2·95	3·75	—	—	—
Blue Serge over ¼" rings ...	0·68	0·97	1·01	43·4	67·2	75·5
Blue Serge + suit lining + shirting	0·93	1·48	1·73	22·5	49·8	58·1
Ditto over rings	0·60	0·79	0·85	49·9	73·2	79·4

Table III

Description of Test	Conductance			T.I.V.		
	Still Air	Moderate Air Movement	Strong Air Movement	Still Air	Moderate Air Movement	Strong Air Movement
Girdle + wool underwear + weighted silk	0·83	1·35	1·52	30·5	54·2	63·0
Girdle + wool underwear + cotton print	0·82	1·28	1·44	31·2	56·7	66·1
Girdle + wool underwear + flannel	0·80	1·17	1·33	33·2	60·4	68·0
Girdle + wool underwear + jersey	0·67	0·91	0·98	43·9	69·1	76·2
Girdle + weighted silk	0·97	1·73	2·03	18·8	41·4	50.7
Girdle + cotton print	0·96	1·69	2·04	19·5	42·7	50·4
Girdle + flannel	0·94	1·58	1·87	21·5	46·4	54·6
Girdle + jersey material	0·82	1·14	1·28	31·8	61·2	68·8
Shirting + suit lining + serge	0·93	1·48	1·73	22·5	49·8	58·1
Girdle + silk slip + weighted silk	0·95	1·71	2·10	20·7	42·1	49·0
Girdle + silk slip + cotton print	0·91	1·55	1·95	24·1	47·4	52·8
Girdle + silk slip + flannel	0·88	1·41	1·60	26·5	52·2	61·3
Girdle + silk slip + jersey	0·75	1·10	1·20	37·0	62·9	70·9
Slip silk + weighted silk	1·12	2·40	3·02	6·4	18·7	26·8
Silk Slip + jersey	0·86	1·35	1·54	28·3	54·1	62·5
Silk Slip + weighted silk over ¼″ rings	0·67	0·88	0·97	44·2	70·1	76·6

Received 15/4/40

Correspondence

REGAIN CALCULATORS

To the Editor of the Journal of the Textile Institute.

Dear Sir,

The description in your pages recently of two regain calculators seems to me to imply a serious reflection on our textile education. The calculation of regain is a matter of simple proportion, one of the easiest things to do on a slide rule, and if there is really a demand for these specialised calculators it is obvious the slide rule has not been taught either as widely or as well as it should be. One of the specialised calculators has slide-rule scales and therefore the same accuracy but the calculator described in your September issue appears to use either squared paper or hand-marked scales. As far as I know, squared paper lithographed from engine-divided originals is available only in small sizes and machine-ruled square paper is notoriously inaccurate both in regularity of division and parallelism. Even when marked out on an engineer's drawing board by a skilled draughtsman I cannot see the calculator coming anywhere near a slide rule in accuracy. The scales of the latter, engine-divided on a relatively rigid base can be read if necessary through a magnifying glass to a far greater accuracy than is possible in any graphical method.

(Signed) A. W. STEVENSON.

Galashiels,
30th September, 1940.

THE JOURNAL OF THE
TEXTILE INSTITUTE

TRANSACTIONS

13—THE DETERMINATION OF IRON AND CHROMIUM IN COTTON

By M. E. PROBERT, PH.D., and (Miss) M. B. PATERSON.

(The British Cotton Industry Research Association)

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The analytical methods described in this paper were investigated primarily with the object of determining the iron and chromium contents of finished cloths dyed with the mixed oxides of those metals. Such cloths generally contain from 0·5 to 5·0 per cent. of iron oxide and from 1·5 to 4·5 per cent. of chromium oxide, but the methods should prove sufficiently elastic to be readily applied in the analysis of other kinds of cotton materials for which the iron and chromium contents are of importance.

The procedure most commonly adopted for determining iron and chromium in yarns and cloths is based on the usual method of analysis of chrome-iron ores, namely, fusion of the mineral matter with sodium peroxide followed by gravimetric or volumetric determination of iron and volumetric determination of chromium as dichromate.

Fusion methods have several disadvantages. In the first place the hygroscopic nature and instability of sodium peroxide render it inconvenient to use; secondly, alkaline fusion is somewhat uncertain in its action and if any of the mineral matter escapes attack this is not detected until the melt has been dissolved and the solution acidified. A third disadvantage is the attack of the vessels employed. Nickel crucibles are most generally used but their life is rather short* and any particles of oxide detached from them are liable to be mistaken for unfused iron or chromium oxide and may cause uncertainty as to whether fusion has been complete. Porcelain crucibles will not survive more than about four fusions and lead to undesirable contamination with silica and alumina.

For accurate work it seemed desirable to replace alkaline fusion by solution in acid media if possible. Search of the literature showed that although numerous alkaline fluxes have been suggested only a very few methods involving the use of acids were available. A number of workers have proposed the use of mixtures of perchloric acid or potassium chlorate with nitric or sulphuric acid and Gröger[1] states that although nitric acid and potassium chlorate will not dissolve chromite it dissolves chromic oxide and most of its compounds. Experiments with this mixture showed that the ashes from a number of cloths dyed with iron and chromium oxides were dissolved completely in a short time on a boiling water bath and this method of solution has proved generally applicable. Several digestions can be carried out simultaneously with very little attention and on this account the method is probably more rapid than fusion methods which require careful individual attention.

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* Nickel crucibles are stated to lose about 0·1 gram in weight during each fusion and to last for 15-25 analyses (Mellor and Thompson: "A Treatise on Quantitative Inorganic Analysis," 2nd Ed., p. 528)

For the separation of iron and chromium two general methods are available, viz. treatment with alkaline hypobromite or treatment with sodium peroxide or hydrogen peroxide in alkaline solution. Since chromium is determined as dichromate, in either case it is first necessary to destroy the excess of chlorate completely. This is done most conveniently either by passing sulphur dioxide into the boiling solution or by boiling it with sodium sulphite in the presence of excess of sulphuric acid.

Considerable difficulty was experienced in effecting complete separation of iron and chromium when using the hypobromite method, particularly if the ratio of iron to chromium was high, for, although chromium salts are very readily oxidised to chromates by this means, it was usually found that part of the chromium was precipitated along with the iron and escaped oxidation. No such difficulty was encountered when using hydrogen peroxide and caustic soda under the conditions described in the experimental part. A further disadvantage of the hypobromite method of separation is the necessity for careful adjustment of the acidity before boiling off the excess of bromine in order to avoid reduction of the dichromate. Excess of hydrogen peroxide can be destroyed rapidly and completely by boiling the alkaline solution in the presence of nickel hydroxide[2].

Iron may be determined by any of the usual methods. The colorimetric method using thioglycollic acid[3] is probably the most rapid and, if a reliable colorimeter is available, gives very accurate results. With due regard to efficient sampling it is desirable that the amount of material taken for analysis should be as small as possible in order to facilitate the initial solution of the oxides, and if iron is determined colorimetrically this may be governed entirely by the approximate chromium content. If the amount of material available is very small both metals may be determined colorimetrically, the diphenylcarbazide method being used for chromium[4].

EXPERIMENTAL

Detailed Procedure

The material (one to three grams according to the anticipated chromium content) is cut into small pieces, dried at 110° C. in a tared weighing bottle and accurately weighed. It is then transferred to a 55-mm. porcelain crucible and ashed in a muffle furnace at as low a temperature as possible—unnecessary ignition must be avoided as this may render the ash difficult to dissolve. The ash is transferred carefully to a 100 c.c. beaker by inverting the crucible inside the beaker to prevent loss in the form of dust and any ash adhering to the crucible is washed into the beaker with three successive portions of concentrated nitric acid, using 10 c.c. in all. Potassium chlorate (0·3 to 0·4 gram) is then added and the beaker, covered with a watch glass, is placed on a steam bath or actively boiling water bath and heated until the contents are entirely free from dark coloured particles; if solution is not complete within 15-20 minutes further small additions of potassium chlorate should be made. The solution is then evaporated to dryness and the residue treated with 5 c.c. of dilute sulphuric acid which is then evaporated off as far as possible. Unnecessary heating of the residues from both of these evaporations should be avoided as this may render them difficult to dissolve again, particularly if china clay is present.

Water is then added and, after heating for about 10 minutes, the solution is transferred to a 250 c.c. conical flask, filtering if necessary. After addition of 2 c.c. of concentrated sulphuric acid and about 4 grams of crystalline sodium sulphite the solution is brought to the boil and allowed to simmer very gently for about 5 minutes. It is important to ensure that the solution smells strongly of sulphur dioxide throughout this period, if necessary by adding a further quantity of sodium sulphite; if any precipitate should form during heating, more sulphuric acid must be added. The solution is then boiled until it no longer smells of sulphur dioxide.

Separation of Iron and Chromium.

The reduced solution is treated with 3 c.c. of 100-volume hydrogen peroxide or an equivalent volume of a weaker solution and 2*N* sodium hydroxide solution is added very gradually until precipitation of ferric hydroxide is complete. It is then made strongly alkaline by adding a further 10 c.c. of sodium hydroxide solution and boiled gently until vigorous effervescence has ceased. The precipitate is then filtered off, washed thoroughly with hot water, and the filtrate and washings collected in a 500-c.c. conical flask.

Determination of Chromium.

The filtrate and washings are treated with 5 c.c. of a 5 per cent. solution of nickel sulphate and boiled for 10 minutes, care being taken to avoid loss by frothing. The solution is then acidified by adding concentrated sulphuric acid—about 2 c.c. in excess of the amount necessary to dissolve the nickel hydroxide completely—and titrated with 0·1*N* ferrous ammonium sulphate, using phenylanthranilic acid as indicator.*

1 c.c. of 0·1*N* ferrous ammonium sulphate ≡ 0·001733 gram of chromium or 02534 gram of Cr_2O_3.

The ferrous ammonium sulphate solution is prepared by dissolving 40 grams of the pure salt in about 300 c.c. of water, adding 20 c.c. of concentrated sulphuric acid and diluting to 1 litre. It should be standardised daily by titration with 0·1*N* potassium dichromate (4·9035 grams $K_2Cr_2O_7$ and 200 c.c. concentrated sulphuric acid per litre).

Determination of Iron.

The ferric hydroxide precipitate is dissolved in hot 2*N* hydrochloric acid, the filter washed thoroughly and the solution and washings made up to 500 c.c. A suitable aliquot portion is then transferred to a 50 c.c. measuring flask, diluted to about 45 c.c. with distilled water, treated with three drops of thioglycollic acid and the solution mixed thoroughly. Two c.c. of ammonium hydroxide solution (Sp. Gr. 0·880) are then added and the whole is diluted to 50 c.c. A suitable depth of shade for colorimetric comparison is given by a solution containing about 0·0001 gram of iron in 50 c.c. The amount of the unknown solution taken for the final matching should therefore be chosen by rough preliminary trials against a solution containing 10 c.c. of a standard iron solution containing 0·00001 gram of iron per c.c.† treated as above and diluted to 50 c.c.

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* The indicator is prepared by dissolving 1·065 gram of phenylanthranilic acid in a solution of sodium carbonate—0·53 gram of the anhydrous substance dissolved in a small quantity of hot water—and diluting to 1 litre.

† The standard solution is prepared by dissolving 3·512 grams of pure ferrous ammonium sulphate in about 50 c.c. of 2*N* sulphuric acid and diluting to 500 c.c. Ten c.c. of this solution are then diluted to 1 litre with distilled water containing about 50 c.c. of 2*N* sulphuric acid. Each c.c. contains 0·00001 gram iron and is equivalent to 0·00001421 gram Fe_2O_3.

The colorimetric measurements in this work were made with a Bausch and Lomb 50 mm. Duboscq Colorimeter, the mean of ten readings being taken in each determination.

Control Analyses.

(*a*) *Mixtures of pure Iron and Chromium Salts.*

The accuracy of the method was tested by analysis of mixtures containing different proportions of iron and chromium prepared from solutions of pure ferrous ammonium sulphate and potassium dichromate. After complete reduction by means of sulphur dioxide, accurately measured portions of the solutions were evaporated to dryness in 100 c.c. beakers, the residues were digested with nitric acid and potassium chlorate, and the two metals separated and determined by the methods already described. (Table I.)

Table I.

	Chromium—grams Cr_2O_3		Iron—grams Fe_2O_3	
	Present	Found	Present	Found
1	0·061	0·061	0·153	0·152
2	0·153	0·152	0·061	0·060
3	0·076	0·075	0·076	0·076

(*b*) *Analysis of Cloths dyed with Iron and Chromium Oxides.*

In order to test the reproducibility of results five independent analyses were made on a cloth previously cut into small pieces and thoroughly sampled. (Table II.)

Table II.

Chromium (as Cr_2O_3) per cent. in dry cloth	3·30	3·31	3·32	3·30	3·31	Mean 3·31
Iron (as Fe_2O_3) per cent. in dry cloth ...	2·01	1·99	2·00	1·98	1·97	Mean 1·99

(*c*) *Colorimetric Determination of Chromium.*

The accuracy of the colorimetric method for chromium was tested by analysis of five cloths previously sampled and analysed by the ordinary method. The results (Table III) show that both metals can be determined accurately on samples weighing as little as 0·1 gram.

Table III.

Cr_2O_3 per cent.		Fe_2O_3 per cent.	
Titrimetric (1·0-gram samples)	Colorimetric (0·1-gram samples)	Colorimetric (1·0-gram samples)	Colorimetric (0·1-gram samples)
2·40	2·33	1·23	1·18
4·41	4·29	1·90	1·89
4·25	4·12	1·35	1·34
1·95	1·94	—	—
2·69	2·67	4·51	4·59

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1. APR. 1941

THE JOURNAL OF THE
TEXTILE INSTITUTE
TRANSACTIONS

14—SOME EFFECTS OF WORSTED OPEN DRAWING ON FIBRE LENGTH DISTRIBUTION

By RONALD WILLIAMSON, M.Sc.Tech., A.T.I.
(Harlow Fellow of Bradford Technical College)

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INTRODUCTION

The reduction of the worsted sliver to a fine roving, suitable for the spinning operation, unavoidably imposes certain stresses upon the wool fibre, and can materially affect many of its properties. The compilation of this paper is the sequence to a series of studies on some of the physical changes which the fibre undergoes, more particularly in respect to changes of fibre length, as a result of its passage through the group of machines constituting the worsted open drawing process—the system most widely used in this country to effect this reduction.

The central feature of such a study is naturally concerned with fibre breakage. This is an evil which is recognized, in a general way, as being an ever present danger to the processing of all fibres, but the lack of actual data on this point is demonstrated by the very sparseness of comment made upon it in most of the standard writings dealing with worsted drawing. Where breakage occurs it will cause a decrease of mean fibre length in the ultimate rovings, and it is from this point of view that the investigations were commenced. Samples were withdrawn at each stage of the processing, and tests made to ascertain the mean length in each case for comparison with that of the original top.

The second important aspect bearing upon these changes of fibre length is the extent to which the fibre may be permanently extended, due either to changes in its extensibility or to reduction of crimp content. The term " permanently extended " is used advisedly, as temporary changes can be nullified by such means as storage, or the application of moisture and heat.

Other factors, which may influence the results obtained, such as variations in the results given by the fibre length tester, are also discussed.

In the concluding section the results of these several studies are correlated, and from them the amount of fibre breakage has been deduced.

Previous work on this subject has indicated that the mean fibre length of the resultant roving is appreciably reduced as compared with that of the original top. An example may be given of a test made, prior to the commencement of this investigation, on a sample of wool of 64's quality where the fibre length distribution of the top was as shown in Table I, column (1), with the corresponding percentages in column (2). After processing through eight drawing frames, the fibre length distribution was found to be as given in columns (3) and (4). These two distributions are shown graphically in Fig. 1, and the large recorded decrease of length in the roving is at once apparent. Examination of these results shows immediately the scope for further and more detailed investigation.

Table I

Fibre length (Cms.)	Top		Roving	
	Weight (grains) (1)	% weight (2)	Weight (grains) (3)	% weight (4)
14	0·1	0·09	—	—
13	0·2	0·18	—	—
12	0·8	0·73	0·1	0·15
11	2·3	2·10	0·4	0·61
10	5·0	4·57	1·1	1·68
9	9·5	8·70	1·9	2·90
8	14·2	13·00	4·5	6·87
7	15·9	14·55	5·9	9·01
6	15·2	13·91	8·3	12·67
5	12·8	11·71	8·6	13·13
4	12·6	11·53	7·7	11·76
3	10·3	9·42	8·7	13·28
2	6·3	5·76	8·1	12·37
1	2·9	2·65	6·8	10·38
Less than 1	1·2	1·10	3·4	5·19
Mean Fibre Length, cms. ...	5·97		4.36	

Table I and Fig. 1 illustrate the conventional method of presenting the results of tests such as these. They are given here in full and will subsequently be referred to for explanation. At the foot of each column the mean fibre lengths are given.

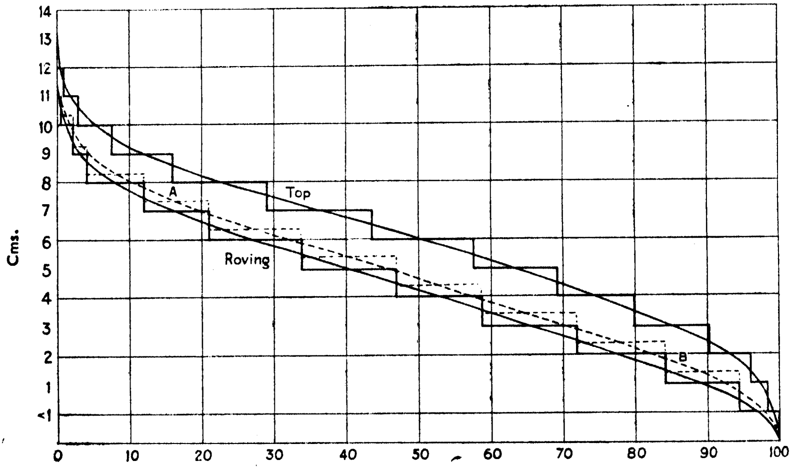

Fig. 1. *AB*—Adjusted Roving

EXPERIMENTAL DETAILS

The treatment of the material in this investigation may be divided into four groups as follows :—

A. One lot of 64's quality was processed with machine settings which approached as closely as possible to those of industrial conditions, and was regarded as the control or standard for comparison for the ensuing experiments in this quality. Three additional lots were then produced by modifying, in turn, the chief points of mechanical adjustment, i.e., those controlling the draft, the twist and the ratch.

B. Four lots were produced with features as in group *A*, but employing 48's quality.

C. A bulk lot of 64's quality was processed normally to the weigh box, at which stage it was separated into four lots. Each of these lots was passed eight times more through the weigh box with settings as in group *A*.

D. As in group *C*, but with 48's quality, and processing six times.

The objects of the last two groups were chiefly for comparison with the products of groups *A* and *B*, as will be explained more fully in the discussion of the results. The slubbings so produced were too irregular in weight to be of commercial value, their use being limited to the purpose for which they were intended, i.e., for fibre testing.

Material. In determining what should be the qualities of wool to be employed it was decided to duplicate all the experiments and select two distinct types, one representing the fine quality, the other the medium quality ranges. Those selected were 64's Australian Merino and 48's Colonial Crossbred. They were received in top form, in a dry-combed condition, and 3 per cent. olive oil was added when entering the can gill; this being the standard amount of oil added.

Processing Particulars. The eight machines which made up the set employed for the 64's quality consisted of:—

Can Gill.
Spindle Gill.
Drawing Box.
Weigh Box.
First Finisher.
Second Finisher.
Reducer.
Rover.

For the 48's quality the second finisher and reducer were omitted, thus giving a set of six machines.

In the discussion of these experiments the slubbings and final roving will be referred to by the machine from which they were produced, and the processings as standard, high draft, high twist, and high ratch respectively. Also the two qualities of wool will be denoted by 64's quality, and 48's quality.

The details of Tables II and III are self-explanatory in giving an account of the passage of the wool through the process and stating the machine settings. For groups *A* and *B*, 10 lbs. of wool were allocated to each lot, and 5 lbs. to groups *C* and *D*.

As stated above the lots termed the standard were treated under conditions which were considered to be similar to those employed in industry for these qualities, but with one important qualification in the draft settings. It will be noted that the drafts do not strictly follow this condition. Thus, the draft of the standard processing for the 64's quality is 5·5 for all processings to the reducer, and the last two processings have been increased merely to obtain the required weight of roving. Under industrial conditions the draft at the first gill box would probably be 5, and rise at each operation until at the rover it would be 6·8-7·0. But had a progressive draft been employed a further variable would have been introduced. For example, if a greater decrease of mean fibre length were noted at, say, the rover than at the gill box, with drafts of 5 and 7 respectively, it could not be known what proportion of this greater decrease was due to such factors as fibre breakage, and what was due to the normally higher draft. To avoid this difficulty the practical drafts, which are to some extent conventional settings, and have been found in practice to be the most convenient, were modified to give a more equal draft, as shown in Table II. The above remarks also apply to the drafts in the 48's quality.

Table II

Process	Machine	No. of slubbings in creel	Theoretical draft	Weight per 40 yds. of slubbing (drams)	Twist inserted (turns per foot)	Ratch (inches)		
						Total*	Front rollers to :— Front Carrier	Back Carrier
	64's Quality							
Standard	Can gill ...	4	5·5	247	—	6·5	—	—
	Spindle gill	4	5·5	201	2·4	6·5	—	—
	Drawing box	4	5·5	149	5·0	6·5	2·75	4·25
	Weigh box	3	5·5	87	5·8	6·25	2·75	4·25
	1st Finisher	3	5·5	47	7·5	6	2·75	4
	2nd Finisher	2	5·5	19·1	14·7	5·75	2·75	4
	Reducer ...	2	6·0	6·2	17·4	5·5	2·75	3·75
	Rover ...	2	6·0	2·1	25·2	5·5	2·75	3·75
High draft	Can gill ...	5	7	242	Approx. as Standard	As Standard		
	Spindle gill	5	7	192				
	Drawing box	5	7	139				
	Weigh box	5	7	97				
	1st Finisher	4	7	57				
	2nd Finisher	3	7·5	22·2				
	Reducer ...	3	7·5	7·5				
	Rover ...	2	7·5	2·3				
High twist	Can gill ...	4	As Standard	242	—	As Standard		
	Spindle gill	4		216	4·5			
	Drawing box	3		127	7·8			
	Weigh box	3		83	9·7			
	1st Finisher	3		51	12·5			
	2nd Finisher	2		20·9	19·8			
	Reducer ...	2		6·5	20·6			
	Rover ...	2		2·4	34·0			
High ratch	Can gill ...	As Standard	As Standard	247	Approx. as Standard	8	—	—
	Spindle gill			218		8	—	—
	Drawing box			146		8	2·75	5
	Weigh box			90		7·75	2·75	4·75
	1st Finisher			47		7·5	2·75	4·5
	2nd Finisher			19		7·25	2·75	4·25
	Reducer ...			6·3		7	2·75	4
	Rover ...			2·1		7	2·75	4
	48's Quality							
Standard	Can gill ...	6	9	331	—	12·5	—	—
	Spindle gill	6	9	250	1·8	12·5	—	—
	Drawing box	5	9	139	4·0	12·5	2·75	7·25
	Weigh box	5	9	75	7·5	12·25	2·75	7
	Finisher ...	4	9	32	14·4	12	2·75	7
	Rover ...	2	10	6·2	24·2	11·5	2·75	6·75
High draft	Can gill ...	8	12	345	Approx. as Standard	As Standard		
	Spindle gill	8	12	265				
	Drawing box	6	12	105				
	Weigh box	6	12	60				
	Finisher ...	5	12	25				
	Rover ...	3	12	6·0				
High twist	Can gill ...	As Standard	As Standard	331	—	As Standard		
	Spindle gill			251	2·4			
	Drawing box			143	6			
	Weigh box			77	9·4			
	Finisher ...			34	24·4			
	Rover ...			6·4	30·5			
High ratch	Can gill ...	As Standard	As Standard	330	Approx. as Standard	13·5	—	—
	Spindle gill			252		13·5	—	—
	Drawing box			139		14·25	3·25	8·25
	Weigh box			77		14·25	3	8
	Finisher ...			35		14	3	8
	Rover ...			6·4		13·5	3	7·75

*In the case of the gill boxes these figures indicate the distances from the front rollers to the centre of the fallers.

Table III

Machine	Roller diameters (inches)		Roller speeds* (Revs. per min.)
	Front	Back	
Can gill ...	2	3	16·5
Spindle gill ...	2	3	16·5
Drawing box ...	4	2·5	65
Weigh box ...	4	2·5	81
1st Finisher ...	4	2·5	125
2nd Finisher ...	4	2	69
Reducer ...	4	2	66
Rover	4	2	66

*Back roller speeds for the gill boxes; front roller speeds for the others. These are the constant speed rollers in each case; the front rollers of the gill boxes and the back rollers for the other machines being varied according to the draft.

It will be noted that the settings all approach the minima which, for practical reasons, could be used. Thus, a smaller draft would have necessitated the choice of either more processes or the opening up of possibilities of an irregular yarn; a lower twist was impracticable as fibre control would have been inadequate at each subsequent stage of processing; and a shorter ratch could not have been used as it would then have been less than the length of the longest fibres and of itself caused fibre breakage. Hence the only direction in which the modified settings for the comparative tests could be made was by increase. Reference to Table II shows the amount of increase which was made for each test.

It should also be noted that the increases were, in every instance, within the limits of good processing, but, on the other hand, they reached near to the upper limits, and little additional increase could have been made without either decreasing mechanical efficiency or lowering the general quality of the material. This demonstrates an interesting point in indicating that only relatively small variations of settings, especially with fine qualities, are permissible if conditions of maximum efficiency are to be maintained.

The actual drafts differed slightly from the calculated ones due to conditions which normally arise in drawing, such as take up, shrinkage, etc. They can readily be found from the information in Table II. Also, the twists stated are calculated. Any divergence from these would be so small as to be of no importance to the objects of the investigation.

Both the can and spindle gill boxes were of the intersecting type, the number of drops per minute of the fallers being 504 in each machine. The top front rollers of the other machines were cork covered. For the last two processes of the 64's quality, which have been denoted by the usual terms of reducer and rover, the same machine was used, small-sized bobbins being used in the latter process.

The humidity of the drawing room was not controlled. Unfortunately, the conditions were rather dry and varied from 40 to 45 per cent. relative humidity. The ill effects of this were avoided so far as possible by storing the tops and all rovings, when not in actual use, in a controlled humidity of 70 ±2 per cent. It is considered that these precautions were sufficient to give satisfactory results. The samples withdrawn from the slubbings for testing were immediately taken to the testing room.

Testing. Samples were taken from the product of each machine in all the processes and stored for a period of at least fourteen days in the testing room, where the relative humidity approximated throughout to 65 per cent., before testing was commenced. They varied from the thick, twistless sliver of the top to the relatively fine slubbings, and final roving, to which twist had been imparted for strength. In preparing them for the fibre length tests, special care had to be taken to ensure the removal of this twist. With the products of the first five machines this was readily performed by hand, but those of the second finisher, the reducer and the rover presented some difficulty. The twist could be removed without difficulty, but these finer slubbings persisted in springing back into their coiled position when released. The best method of overcoming this was found to be as follows :—

The slubbings were broken into lengths of about four feet and each dealt with in turn. One end was held on a table by means of a weight, and the twist then removed by hand in lengths of five to six inches, commencing at the fixed end. The free end was allowed to revolve at will, otherwise the twist removed from one portion would have accumulated at another. Also, as the twist was removed, the fibres were slightly drafted to disturb the positions into which they had become embedded. When all the twist had been removed the roving was laid along the table and the other end secured by another weight. After some two hours in this position the slubbing had lost almost all tendency to re-twist, it was in a far more suitable condition for testing, and enabled tests to be made in a machine originally designed for the testing of tops.

The fibre length distribution of the slubbings was measured by means of the Schlumberger fibre length testing machine which segregates the fibres into groups according to length. These groups were weighed and each expressed as a percentage of the total weight. The examples given in Table I and Fig. 1 illustrate the results of tests made by this machine. In view of the large number of samples tested, the results of the present experiments are not given in full detail ; presentation being confined to the mean fibre length in each case. All these tests were repeated, and as the differences between the first and second tests were slight, averages were taken.

When testing fibres in the form of top, one sliver was of sufficient thickness to make the draws, but a number of finer slubbings had to be placed together in the carriage. The numbers taken for the different forms of slubbing were as given in Table IV.

Table IV

Processing.	Number of slubbings in Schlumberger carriage	
	64's quality	48's quality
Can gill ...	1	1
Spindle gill ...	1	1
Drawing box ...	2	2
Weigh box ...	3	3
1st Finisher ...	4	6
2nd Finisher ...	9	—
Reducer ...	20	—
Rover	48	20

In spite of the precautions taken, as described above, to open out the slubbings and remove all twist, there still remained some difference in the form and density in which the various masses of fibres entered the carriage of the Schlumberger tester for withdrawal by the holder. These ranged, as shown in Table IV, from the single thick slubbing of the can gill, which at no time had been subjected to the stresses set up by twisting, to a group of forty-eight 64's quality rovings, each of which still had some tendency to cling together as thin individual strands. Hence the possibilities of any differences in the manner of withdrawal of fibres from these supplies had to be studied. It was suspected that the fringe formed at the carriage in readiness for the next draw, was somewhat longer in the case of the fibre rovings, in which case a smaller mean fibre length would be given. This can be accounted for when the cycle of motions of the testing machine is considered. The carriage, holding the material, moves forward and presents a fringe of fibres to the jaws of the holder. These jaws grip the fringe, and, as the carriage recedes, the fibres which are held are withdrawn and laid over the rows of faller-pins in readiness for being pressed into them. Meanwhile, during the first stage of the recession of the carriage, the fine pins of the carriage-cover are lifted out of the top—or slubbing, as the case may be—to allow the latter to be drawn forward a distance sufficient to form a fringe for the next draw. The pins now fall, penetrate the top, and hold the fibres in this new position. This substantially occurs when fibres in top form are tested, but when the machine is used for testing the finer slubbings some extra fibre movement may occur due partly to (*a*) the less uniformly open conditions of the mass of fibres, but chiefly to (*b*) the greater inter-fibre relationships between the fibres about to form the fringe and those already held by the holder and being withdrawn from the carriage. Therefore, at the completion of the cycle, many fibres may have moved forward in the fringe a greater distance than that permitted by the raising of the pins. It should be noted that this is the only section of the machine at which any such differences will arise, because, as the fibres are drawn from the carriage, they lose their relationship with each other and become individual fibres once more.

In order to ascertain and measure any differences in the length of the fringe due to such fibre movement, samples were taken when testing the tops, the weigh box slubbings and the final rovings, by cutting away typical fringes from the carriage. The mean length of the portions of fibres constituting each fringe was obtained by taking five hundred of the fibres for measurement. In order to avoid any tendency to select the longer and more prominent fibres, withdrawal from the fringe was effected in a series of small groups or tufts, and every fibre in each tuft was tested. The measurement was accomplished by the simple expedient of laying a ruler, with a millimetre scale, on a board covered with black fabric. The samples to be measured were gripped by a pair of pointed tweezers and held in a straight position, but without removing the natural crimp, in front of the scale.

In view of the necessity for this work of reliable and accurate data regarding any fibre extension, a special extensometer was constructed. This is described below and shown diagrammatically in Fig. 2.

A horizontal bar *A*, 28 centimetres in length, is supported by three pillars, *B*, *C* and *D*. A centimetre scale is marked along its upper surface. It carries an arc shaped plate *E* calibrated to a scale denoting centimetres, and an upright bracket *F*, which can be fixed, by means of a screw *G*, at any position along *A*. One end of the fibre is fixed in *F* by means of the clamp surfaces and screw at *H*. J_1, J_2, J_3 and J_4 are the four arms of a unit suspended on agate edges on two supports, *K*. A weight pan is suspended on an agate edge from the arm J_1. This unit, along with the weight pan, forms a self-balancing system. At the end of the arm J_2 are clamp surfaces and screw, by means of which the other end of the fibre is fixed, and the tip of the arm J_3 is pointed and acts as indicator in front of the scale on *E*. The attachments *N* and *O* each carry a rubber-covered bar 2·5 centimetres in length, and can be adjusted to any desired position on the pillars *C* and *D*. The attachment *O* is situated beneath the arm J_3 and is set in such a position that when the latter rests upon it the pointer indicates zero on the scale *E*. When J_3 is in this position, J_2 is directly over the zero mark of the scale on *A*. *N* is in a position above the arm J_3.

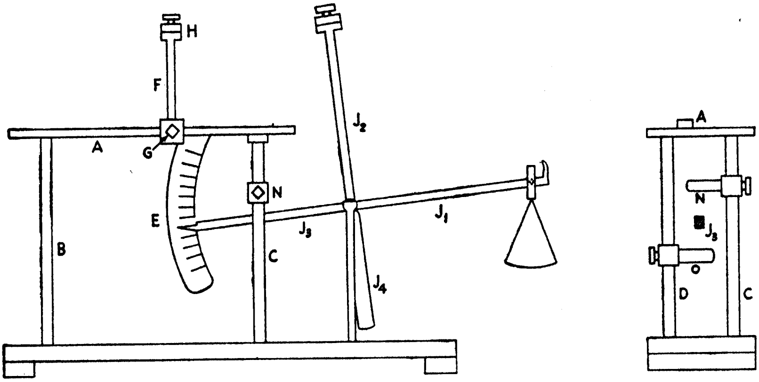

Fig. 2

The method of testing is as follows:—

1. The bracket *F* is set along the bar *A* at a position equal to the test length. If a length of, say, 8 centimetres is decided upon, the length of the fibres would have to be at least 10 centimetres to allow sufficient fibre to be fixed in each clamp.
2. The arm J_3 is held at zero position by means of the attachments *N* and *O*, thus bringing the arm J_2, at the point where the fibre is fixed, over zero on scale *A*. The distance between the two clamps will now be exactly 8 centimetres.
3. The fibre is placed in position.
4. The weight is placed in the pan *M*.
5. The attachment *N* is slowly lifted, and the weight imposes a stress upon the fibre. Care must be taken not to do this too quickly.
6. The extension can be read directly from the position of the pointer on J_3 in front of the scale *E*.

The arms J_1 and J_2 are of equal length and thus the force exerted by the weight in the pan is equal to the tension applied to the fibre. The arms are constructed of such a length, 12·25 centimetres, that their movement through the arc of a circle deviates from a straight line, for a 4-centimetre extension, by 0·13 centimetres only.

The sensitiveness of the machine is equal to that of the normal laboratory balance, that is to 0·1 grain.

DISCUSSION OF RESULTS.

Fibre Length.

The mean fibre lengths of the tests made by the Schlumberger testing machine are given in Tables V and VI.

Table V

64's Quality. Mean Fibre length.

Process	Top	Can gill	Spindle gill	Drawing box	Weigh Box	1st Finisher	2nd Finisher	Re-ducer	Rover
Standard ...	5·996	5·881	5·851	5·766	5·623	5·496	5·487	5·362	4·766
High draft ...	5·996	5·922	5·912	5·785	5·708	5·558	5·475	4·500	4·381
High twist ...	5·996	5·782	5·693	5·602	5·422	5·422	5·096	4·608	4·443
High ratch ...	5·996	5·885	5·795	5·750	5·738	5·543	5·488	5·248	4·822
Grand means	5·996	5·867	5·813	5·726	5·623	5·487	5·386	4·929	4·603
	100	97·7	96·9	95·5	93·8	91·6	89·6	82·2	76·8

Table VI

48's Quality Mean Fibre length.

Process	Top	Can gill	Spindle gill	Drawing box	Weigh box	Finisher	Rover
Standard ...	12·637	12·645	12·710	12·639	12·596	12·547	12·342
High draft ...	12·637	12·700	12·663	12·610	12·593	12·480	12·122
High twist ...	12·637	12·654	12·638	12·668	12·525	12·410	12·268
High ratch ...	12·637	12·640	12·683	12·653	12·569	12·441	12·276
Grand means	12·637	12·660	12·673	12·642	12·571	12·469	12·252
	100	100·2	100·3	100	99·5	98·6	96·9

These results are discussed here in general terms, a more detailed consideration being given in the concluding section. At the foot of each column the variations of the grand mean fibre lengths have been expressed as percentages of the top lengths.

64's *Quality*. Examination of the results in Table V shows immediately a decrease of fibre length with each successive stage of drawing, and is in general agreement with previous work. The second outstanding feature is that much greater decreases occur at the later stages of processing than at the earlier ones. For example, the spindle gill shows a decrease of 0·3 per cent. as compared with one of 5·4 per cent. at the rover. The explanation of this is to be found in the study of the change in the composition of the slubbing from a thick, loose, lofty sliver, sufficiently bulky to withstand processing without twist, to a delicate, fine roving reinforced by twist, which amongst other things, causes greater density and closer relationship between the fibres. Also, the number of fibres in any cross-section of the roving has been greatly reduced, so that each fibre has to withstand a greater proportion of the stresses imposed at the rover than it had during the early stages of drawing.

The standard processing calls for no special comment, the decreases being in accordance with the above remarks.

The high draft processing draws attention to two facts, (1) the decrease of mean fibre length, in passing from top form to final roving, is greater than that of the standard by 6·4 per cent., caused, no doubt, by the greater fibre disturbance, but (2), each of the first five processes has recorded a higher mean length than the standard processing at the corresponding machines. These findings are discussed in the section referring to fibre extension.

From the results of the high twist processing it is to be seen that an appreciably greater reduction of length occurs when twist is increased, this being greater than that of the standard by 5·6 per cent. This modification of standard conditions, by increase of twist insertion, was the only one which gave indications of causing a decrease of processing efficiency. A greater amount of fibre breakage may be expected on account of the higher stresses set up during the drafting of the firmer slubbing. But further complications were set up by increasing the twist. A stronger slubbing was produced, but this initial advantage was evidently more than offset by the greater difficulties of manipulation at the next process. It may be said that the insertion of excessive twist causes a smaller output, a greater cost, greater fibre breakage, and often more difficult processing, and can only be described as a necessary evil to be kept at a practical minimum.

The high ratch processing shows a rate of decrease of fibre length distribution very similar to that of the standard, and indicates that changes of ratch within the prescribed limits have little or no effect in this direction. It was apparent, however, that fibre control was affected, and the risk of such faults as less even fibre distribution was increased.

Three interesting general features to be noted in the groups of lengths from which these means have been obtained were:—

(1) The number of fibres from the top and the can gill of 14 centimetres and more, was sufficient to weigh 0·1 grain, the smallest weight increment used. But this upper limit was decreased with each successive slubbing, until finally at the roving it was reduced to 12 centimetres. This would appear to be a tremendous decrease, but too much importance is not attached to it, because the weights are so small. The sum of the three groups, 14, 13 and 12 centimetres, was, in every instance, less than 1 per cent. Further, it must not be inferred that there were no fibres above these lengths—say, 12 centimetres for the rovings—but that the total weight of these longer fibres was appreciably less than 0·1 grain, and they were therefore included in the 12-centimetre group.

(2) As the proportion of long fibres decreases with repeated processing, so the proportion of short fibres increases. In the extreme case of fibres of less than 1 centimetre in length, this increase is more than three-fold from top to roving.

(3) In spite of the decreased mean length, the modal length was evidently maintained throughout the various slubbings, and in some tests even showed signs of slightly increasing. Two reasons are given in explanation of this, (*a*) a much greater proportion of long fibres, than short ones, was broken, and (*b*) one or both of the broken portions of many of these fibres would be of a length nearer to the mean and so take the place of other fractured fibres originally of mean length. This is a matter of some importance as it demonstrates that the larger groups which constitute the " body " of the top have not been reduced.

48's *Quality*. The following comments may be made with respect to the results given in Table VI.

A. Though a general decrease of mean length is found, it is as surprisingly small as that of the 64's quality is large. A decrease of a smaller order was anticipated, but not to the extent shown here. The causes of this difference between the two qualities are attributed to :—

(1) The stronger and tougher nature of the medium quality which is of Crossbred origin, whilst the 64's quality is a Merino type of wool ;

(2) The straighter, though less resilient properties of the former ;

(3) Its greater fibre diameter and smaller number of serrations per unit length, which will allow the fibres as a mass to be drafted with less frictional resistance, and

(4) The fewer processes to which it is subjected.

Of the factors adversely affecting the 48's quality may be mentioned its greater length and the higher draft at each machine ; but, again, counterbalancing these is its lower twist content.

B. A still more surprising feature is that the slubbings of the gill boxes, instead of decreasing, actually show an increase of mean length. Though small, this increase is too regular in the four processings to be an anomaly due to sampling errors, and can be explained only by fibre extension having had a greater effect than fibre breakage. Therefore, further discussion on this point is deferred to the section on fibre length and extension.

C. With the exception of final roving of the high draft, which shows a decrease of 17 per cent. more than standard, no appreciable differences can be found in the comparative tests, and apart from this single instance, the increases of the various machine settings have shown little or no effect on the fibres. Also, apart from the first processing at the can gill, where the mean length has risen to 12·7 centimetres, the high draft processing has not produced higher mean lengths than the standard such as were found with the 64's quality, although except for the roving mentioned above, these mean lengths are slightly greater than those of the high ratch.

Repeat Processing at Weigh Box.

The objects of these tests were to ascertain the changes of fibre length with a constant weight of slubbing, and for comparisons with the findings of the base tests as given in Tables V and VI. For this purpose 20 lbs. of each quality of top were processed under standard conditions to the weigh box, then divided into four lots. The 64's quality was then processed a further eight times in the machine, and the 48's quality six times. Each of the lots was processed with one of the machine settings as given in Table II. The choice of machine for these tests was largely arbitrary, the weigh box being eventually decided upon, as it is one of the machines mid-way in the series for both qualities. To maintain the slubbing weight, the number of slubbings placed in the creel corresponded to that of the draft. Where this could not be arranged, as, for example, with a draft of 5·5, five or six slubbings were set up as required. The actual arrangement was as follows :—

64's *Quality*. Standard, high twist and high ratch, with 5·5 draft, five slubbings for 1st, 2nd, 4th, 5th, 7th, and 8th processes, and six slubbings for 3rd, 6th and 9th processes.

High draft, with 7 draft, seven slubbings at each process except 5th, when six slubbings.

Samples for testing were taken after the 1st, 3rd, 6th and 9th processes.

48's *Quality*. Standard, high twist, and high ratch, with 9 draft, nine slubbings throughout.

High draft, with 12 draft, twelve slubbings throughout.

Samples for testing were taken after the 1st, 3rd, 5th and 7th processes.

The mean fibre lengths resulting from these experiments are shown in Tables VII and VIII. They confirm the previous conclusions that a considerable decrease of fibre length is caused by the operation of drawing, but these decreases vary widely in extent from those of Tables V and VI. Thus, whereas the grand mean length of the roving in Table V has fallen to 76·8 per cent. of the top, the corresponding decrease in Table VII is only to 92·8 per cent. This discrepancy may be due either to a more pronounced effect on the finer rovings, or to the Schlumberger tester not reacting in like manner to the various slubbings. It will be explained later that both these features are operative. On the other hand, this decrease is actually less in Table VI than in Table VIII, i.e., 96·9 per cent., as compared with 94·8 per cent. Examination of the circumstances in which these slubbings have been produced indicates the reasons for these apparently contradictory results, (*a*) two of the last three processes have been omitted from the drawing of the 48's quality so that much of the greater decrease shown in the finer slubbings has been eliminated, and, (*b*) only two processes follow that of the weigh box in Table VI, whilst there are six further processes from this stage in Table VIII and, (*c*) it has been suggested that the fibres are extended by the processing, this being particularly noticeable in the earlier stages of Table VI. Should this be so, the actual decrease of mean length caused by other sources, such as fibre breakage, will be greater than Table VI indicates. This will not appertain to the same extent in Table VIII as the fibres have previously been processed three times. Further discussion of this theory will also have to be deferred until other aspects have been considered.

Table VII
Repeat processing of 64's quality at Weigh Box.

Process	Number of times processed			
	1	3	6	9
Standard... ...	5·697	5·474	5·351	5·326
High draft ...	5·697	5·547	5·320	5·254
High twist ...	5·697	5·461	5·219	5·188
High ratch ...	5·697	5·559	5·377	5·379
Grand means ...	5·697	5·510	5·317	5·287
	100	96·7	93·3	92·8

Table VIII
Repeat processing of 48's quality at Weigh Box.

Process	Number of times processed			
	1	3	5	7
Standard... ...	12·596	12·419	12·225	12·022
High draft ...	12·596	12·305	12·062	11·999
High twist ...	12·596	12·198	12·152	11·732
High ratch ...	12·596	12·441	12·157	12·028
Grand means ...	12·596	12·341	12·149	11·945
	100	98·0	96·5	94·8

No attempt has been made to attribute the decreases of mean fibre length as found above to fibre breakage, even though they are substantially in accordance with the findings of previous work. Before doing this, other factors which may have had influence on these results are discussed in the following three sections.

Length of fringe of the Schlumberger Carriage.

The results of these tests are given in Table IX, and the following points are to be noted:—

(*a*) It will be seen that, as anticipated on page 240, the fringe presented by the 64's quality shows a decided increase in the mean length at each successive test, and that the increase is much greater from weigh box to rover, than from top to weigh box. On the other hand the 48's quality does not show an increase in length of fringe until the later processes.

(*b*) Another point arising from these results is the greater variations of the fibre length in the fringes of the later processes, no doubt due to the greater fibre disturbance.

Table IX. Mean length of Schlumberger Fringe.

Material	Mean length, centimetres		
	Top	Weigh box slubbing	Roving
64's quality	0·773±0·0095	0·915±0·0122	1·206±0·0181
48's quality	1·002±0·0157	0·983±0·0146	1·068±0·0144

Table X. Adjustments to be made for differences of fringe length.

Material	Can gill	Spindle gill	Drawing box	Weigh box	1st Finisher	2nd Finisher	Reducer	Rover
64's quality ...	0·020	0·056	0·097	0·142	0·200	0·262	0·338	0·433
48's quality ...	0·000	0·000	0·000	0·000	0·020	—	—	0·068

(*c*) Thirdly, the length of fringe of the top of 48's quality is 2·29 millimetres greater than the fringe of the 64's quality. This raises the question as to whether fibre length, diameter, and other fibre characteristics can affect the testing of tops in the Schlumberger machine. It is one which invites further investigation as the same tendencies are likely to appear in other types of fibre length testing apparatus.

The results of Table IX have been plotted to form graphs, from which adjustments have been derived to make allowance for the differences. These are given in Table X and have been applied in Tables XV and XVI on page 254.

Fibre Elongation.

It has been assumed that the only means by which the fibre length may be permanently increased are either by removing some of the crimp and giving to the fibre a straighter and less wavy character, or by increasing its natural length *at the expense of its properties of extension and elasticity.* From this assumption the extensible properties of the fibres have been studied with a view to attributing any such changes to changes of fibre length.

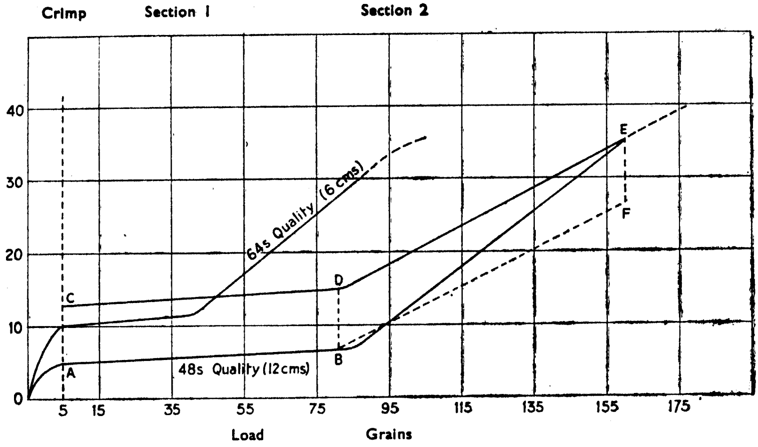

Fig. 3

Tests made on the Schopper Fibre Tester failed to reveal any changes of either fibre strength or extension at break, the results being far too varied for any conclusions to be reached. They did, however, emphasize the difficulties of obtaining accurate values by direct methods and the necessity for more detailed investigation if such values are to be obtained. The question of fibre strength, as it was of no more than supplementary interest to this work, was not pursued further, but closer study of the extensibility was deemed essential. This necessity led to the construction of the extensometer described on page 241.

The principle of testing was similar to that which has been employed by Speakman[1], who increased the load on the fibre by small increments at prearranged intervals. These increments were applied throughout the present investigation at intervals of thirty seconds, regardless of whether or not equilibrium had been reached. The differences in procedure from those of the above author were adopted on account of the different objects of this paper, and the changed circumstances which these objects necessitated.

In all tests the fibre was purposely mounted in a loose condition to ensure that it was in no way extended before the loads were applied. The fibre was then placed under a small tension, 0·1 grain for the crimp experiments and 2 grains for the extension proper, to remove the slackness and place the fibre at a suitable tension without affecting any of the characteristics to be tested. Fig. 3 gives the form of extension of the fibres as the increments of weight were successively increased, and shows that discussion can be made most conveniently in three sections :—

(*a*) crimp, which is acted upon by small loads ; loads of 4 and 6 grains, for the 64's and 48's qualities respectively, being sufficient to remove the crimp,

(*b*) then follows a range of tensions through which the fibre itself begins to extend at a slow but very regular rate, and

(*c*) a period of much more rapid extension during which, though there is some degree of regularity of the *rate* of extension, great variations of individual extension/load properties were noted in different fibres. Also, the fibres usually reached breaking-point in this section. Speakman[2] has named these two latter periods Sections 1 and 2 respectively, and they will be referred to in this way. He also established a third section, but in the present tests only a small proportion of fibres reached this stage. The significance of the absence of this third section will be discussed later.

Crimp. Tension was applied to fifty fibres from each of the slubbings, and the mean percentages of extension* of fibre length due to crimp removal are given in line (1), Tables XI and XII. They are expressed as percentages of the initial length, i.e., the length before the removal of the crimp, as it is to this length that adjustment will have to be made. Although there are divergent results at the can gill and finisher, 48's quality, and the 1st finisher, 64's quality, a definite decrease of crimp content has been found, which illustrates that the fibres are straightened, and in effect elongated to this extent by crimp removal. The actual loss of crimp at each process is included in line (2) as a percentage of the crimp content of the fibres in top form. A notable feature here is the similarity of the loss in the two qualities.

The decreases of crimp, calculated from line (1), have been arranged in the form of a graph, and, from the line so produced, values representing the corresponding increases of recorded fibre length at each stage of drawing were produced. These values, given in line (3) are the amounts by which the results of Tables V and VI will be adjusted.

Table XI. 64s Quality.

	Top	Can gill	Spindle gill	Drawing box	Weigh box	1st Finisher	2nd Finisher	Re-ducer	Rover
(1) Crimp content	10·00 ± 0·098	9·70 ± 0·076	9·66 ± 0·070	9·50 ± 0·061	9·47 ± 0·064	9·10 ± 0·077	9·22 ± 0·073	9·17 ± 0·084	8·94 ± 0·063
(2) Percentage loss of crimp	0·0	3·0	3·4	5·0	5·3	9·0	7·8	8·3	10·6
(3) % Adjustment to mean lengths for loss of crimp	0·00	0·30	0·40	0·49	0·58	0·70	0·81	0·93	1·06

Table XII. 48s Quality.

	Top	Can gill	Spindle gill	Drawing box	Weigh box	Finisher	Rover
(1) Crimp content ...	4·90 ± 0·055	4·67 ± 0·049	4·71 ± 0·062	4·56 ± 0·053	4·54 ± 0·063	4·35 ± 0·055	4·39 ± 0·074
(2) Percentage loss of crimp	0·0	4·7	3·9	6·9	7·3	11·2	10·4
(3) % Adjustment to mean lengths for loss of crimp	0·00	0·22	0·28	0·34	0·41	0·48	0·53

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* The impression may be formed that these percentages are unduly small, as examination of any sample of wool of equivalent quality will indicate, but it must be appreciated that most of the crimp has been removed in the processes prior to drawing. For example, tests have been made on fibres of 64's quality, (*a*) before combing, (*b*) after top finishing, when it was found that the crimp at the latter stage had been reduced by some 69 per cent. It is hoped to discuss this matter more fully in a subsequent paper.

Section 1. The application of small loads below those required to remove the crimp does not have any appreciable effect on the actual fibre length and these loads may be sustained for long periods without even causing the " creep " referred to by Speakman in his writings quoted above. Tensions above these, however, do extend the fibre, and it is these elongations which are now to be discussed. This section deals with the small even extension which takes place with loads up to approximately one-half of the average breaking load. The regularity and uniformity of extension throughout this range of tensions make these results of great significance.

Loads of 10, 20, 30 and 40 grains were applied to fifty fibres, of 6 centimetres test length, from the top, the weigh box slubbing and roving, for the 64's quality. Similarly with the 48's quality, loads of 20, 40, 60 and 80 grains were used with 12 centimetre test length. Mean values for the extensions at each of these loads were obtained and found closely to follow a straight line law represented by the formula $y=ax+b$, where y is the extension in millimetres, x the load applied in grains, and a and b constants. These values were produced in graph form and values for a and b obtained, giving the results as shown in Table XIII.

Table XIII. Fibre Extension, Section 1.

Material	Slubbing ...	$y=ax+b$
64's Quality	Top	$y=0{\cdot}044x+0{\cdot}60$
	Weigh box ...	$y=0{\cdot}044x+0{\cdot}51$
	Roving ...	$y=0{\cdot}044x+0{\cdot}48$
48's Quality	Top	$y=0{\cdot}021x+0{\cdot}78$
	Weigh box ...	$y=0{\cdot}021x+0{\cdot}72$
	Roving ...	$y=0{\cdot}021x+0{\cdot}63$

These results give no indication of an increased rate of extension so further details have not been given, but some discussion on these findings is necessary.

In both qualities the value of b is highest in top form and lowest in the roving. These figures, though for several reasons they are not strictly comparable, support the results of the above section on crimp. But it is the values of a which are of the greatest moment as they give a measure of the rates of extension of the fibres in the various slubbings. With both qualities these values are in every case the same, calculated to the second decimal place, showing, as stated above, that the rate of extension over this range of loads has not been changed by the processing. There is, however, a further application of these results. Speakman[8] makes constant reference to the fact that a once extended wool fibre remains permanently more extensible at low tensions. The importance of this cannot be too strongly stressed. A fibre of 48's quality was loaded up to 160 grains under the present conditions and the consequent extension was as shown in Fig. 3 along the line AB. The tension was then removed and after an interval of 30 minutes the application of the loads was repeated. The fibre extension was then found to be as shown by the line CD with a value of a of 0·029. Thus when two fibres of otherwise identical characteristics, are strained to different degrees, they react differently to tension, and will give different values for *a*. From the results set out in Table XII, no such differences are to be found and this is taken as a strong indication that the extensible properties of the materials have not been affected by the drawing process, and that any strains to which the fibres have been subjected in the earlier processes such as carding, preparation and combing, have not been accentuated.

Section 2. The above period of low and uniform extensibility is followed by one of much greater extensibility and variability ; and the difficulties of direct accurate measurement encountered during the Schopper tests again appeared. Examination of individual results of tests made in this section show that the liability to enormous variations is due to a combination of several factors.

(*a*) The load at which this section or phase is entered is not the same with all fibres. It was noted to diverge by 10 per cent. from 45 grains for the 64's quality and from 90 grains for the 48's quality.

(*b*) There is a similar variability at the upper limit of the section.

(*c*) The rate of extension differs from one fibre to another.

(*d*) The greatest obstacle, however, to the acquisition of accurate information regarding fibre extensibility is presented by the fibres reaching breaking point at all points along this range. From a series of tests upon 250 fibres of each quality, commencing at a load of 2 grains, the extension-at-break distributions were as follows :—

Material	Percentage extension-at-break						
	0–10	10–20	20–30	30–40	40–50	50–60	60–70
64's Quality	2	63	105	49	21	9	1
48's Quality	33	93	81	42	1	—	—

Nevertheless, underlying these variations, certain characteristics have come to light to assist in reaching a conclusion to the problem in hand.

Study of results from fibres which broke at low extensions indicates that the form of extension is not usually altered when approaching the breaking point, and that fracture is due to local weakness of the fibre, in the absence of which the fibre would have been extended normally. This implies that, in spite of early breakage, the extensible properties of the fibre as a whole are not materially different from those of other fibres, and in ascertaining the mean rate of extension of a sample group of fibres they may be ignored. Further, any such points of weakness will probably be acted upon more readily with sudden tensioning. Speakman[4] has stated that the fibre is elastic up to 70 per cent. of its length. Also, that where the rate of application of tension is very sudden[5] smaller extensions at break are highly probable. These two facts suggest that, where the imposition of stress is instantaneous, as in the case of the drawing operation, the fibre will almost invariably break before the elastic limit is reached, and that the fibres which have escaped breakage have not been extended to this limit. This is given as the second indication that the extensible properties of the fibres have not been changed.

When a fibre which has previously been extended, and its elongation at small tensions remains greater than it was originally, is subjected to tension a second time, the greatest point of difference between its extension in the two conditions is found at *BD*, Fig. 3. Although the rate of extension is greater in Section 1, it is smaller in Section 2. In other words, where a fibre has been pre-extended to a greater degree than another otherwise identical fibre, the extension of the former may be represented by *DE*, hence *BF*, and the latter by *BE*, giving a difference of extension *BD** equal to *EF*. So if the mean *rates* of extension can be ascertained, any such differences may be established. These increases could not be calculated as in Section 1, because of the variations mentioned above, but when the rate of increase of each individual fibre is obtained, instead of mean values of extension with a particular range of loads, the variations (*a*) and (*b*) above can be eliminated, leaving only the comparatively small variations of the rates of increase themselves. Also, until the upper limit of this section is approached, the sequence of these increases each approximates to uniformity, and graphically, to a straight line. Hence, if the range of extensions is restricted to the point below where these upper limit deviations appear, the rate of extension of each fibre may be considered to be perfectly uniform, the formula $y=ax+b$ again applied, and values of a obtained. The mean fibre extensions of this section, in millimetres for load increments of 10 grains, are given in Table XIV, along with the values of a. These results, though somewhat variable, particularly with the 64's quality, are in complete agreement with the above findings in indicating that the mean rates of extension are not affected by the processing.

Table XIV. Fibre Extension, Section 2.

Material	Slubbing	Mean extension per 10 grain increase (millimetres)	"a"
64's Quality ...	Top	3·9±0·21	0·394
	Weigh box ...	3·6±0·23	0·367
	Roving ...	4·0±0·24	0·401
48's Quality ...	Top	2·5±0·10	0·251
	Weigh box ...	2·6±0·10	0·262
	Roving ...	2·6±0·09	0·263

During the discussion in the previous sections, indications have been noted of a greater increase of length being caused by a higher draft, e.g., page 245. Tests have been made on the slubbings from the different settings, but in no instances were differences to be noted to substantiate this impression.

To summarize this section on fibre length, from three distinct aspects it has been demonstrated that there are no indications of the drawing processing having caused increase of fibre length, and these, when considered in conjunction with the findings of Speakman, offer ample confirmation of this as a fact. Reduction of crimp content has, however, been noted, giving to the fibres an increase of length when not under tension. Adjustments will be made in accordance with the increases given in Table XIV.

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*It should be noted that this difference may not be found in Section 1 as the conditions of mounting in the extensometer can be different in the two fibres.

Waste

The formation of waste is a further factor which must be considered as a possible cause of change of fibre length distribution. Lap waste will not have any effect as it is made on normal length distribution; while roller and "rubbing" waste were found to be of negligible quantity, the cork covered rollers reducing the latter two to a few single fibres. Fly waste, however, as it would be composed of a preponderance of short fibres, would give a higher mean fibre length in the Schlumberger tests. Decrease of slubbing weight on this account should not be confused with other "invisible" losses, such as loss of moisture, which will affect all the fibres. With such small lots as were used in this investigation it was impossible accurately to gauge the amount of fly waste, but study of the loss of bulk lots as processed under industrial conditions indicates that it is very slight, probably no more than a small fraction of 1 per cent. Therefore, whilst appreciating the effects of these losses, in the absence of actual data, and recognising their small extent, changes of fibre length distribution due to waste are ignored.

CORRELATION OF RESULTS AND CONCLUSIONS.

From the investigations discussed in the preceding sections it has been found that the decreases of mean fibre length have been influenced by:—

(*a*) the differential action of the fibre length testing machine which records a shorter mean length for a fine roving, than for the same material when in top form, due to the formation of a longer carriage fringe. Adjustment for this is made by the addition to each slubbing of the length given in Table X.

(*b*) the partial removal of crimp. Differences on this account are adjusted by decreasing the results from (*a*) above in accordance with the percentages of line (3), Tables XI and XII.

The revised mean lengths, expressed as percentages of the original top length, are shown in Tables XV and XVI. In the case of the 64's quality it will be seen that the adjustment to be made for fringe length is much greater than that required for crimp content, and the decrease of fibre length recorded in Table V is too large by the following percentages:—

Can gill	Spindle gill	Drawing box	Weigh box	1st Finisher	2nd Finisher	Reducer	Rover
8·7	19·4	24·4	29·0	34·5	36·3	27·0	27·2

These large changes, however, are not to be found with the 48's quality, both the fringe length and the crimp reduction being smaller relative to the fibre length. The adjustments have been made as with the 64's quality. Two points of interest are to be noted:—

(1) as shown in Table X, with the slubbings from the first four processings, there is no increase of fringe length, and the adjustments to the fibre lengths necessitated by diminution of crimp content reduce the mean lengths of the slubbings to those of the original top. This indicates that the fibre breakage in the gill boxes is negligible. Thus in Table XVI the relative fibre length distributions are 100, 99·9 and 100, for the top, can gill, and spindle gill.

(2) the later processings are accompanied by an increasing effect, until, at the final process, the effect almost exactly counterbalances that of the crimp decrease, i.e., the grand means of the roving in Tables VI and XVI are 96·9 and 97·0 per cent. respectively.

Table XV. 64's Quality.

Process	Top	Can gill	Spindle gill	Drawing box	Weigh box	1st Finisher	2nd Finisher	Reducer	Rover
Standard	100	98·1	98·1	97·3	95·6	94·3	95·1	94·2	85·8
High draft	100	98·8	99·1	97·6	97·0	95·4	94·9	79·9	79·4
High twist	100	96·5	95·5	94·6	92·3	93·1	88·6	81·7	80·5
High ratch	100	98·2	97·2	97·0	97·5	95·1	95·1	92·3	86·7
Grand means	100	97·9	97·5	96·6	95·6	94·5	93·4	87·0	83·1

Table XVI. 48's Quality.

Process	Top	Can gill	Spindle gill	Drawing box	Weigh box	Finisher	Rover
Standard	100	99·8	100·3	99·7	99·3	99·0	97·7
High draft	100	100·3	99·9	99·4	99·2	98·4	95·9
High twist	100	99·9	99·7	99·9	98·7	97·9	97·1
High ratch	100	99·8	100·1	99·8	99·1	98·1	97·2
Grand means	100	99·9	100	99·7	99·1	98·4	97·0

The decreases which still remain in the various mean fibre lengths are directly attributed to fibre breakage. In the examination of these results, the most striking general feature is still the great differences between the effect of open drawing on the two qualities. The comments on pages 244 and 245 still hold good. The 48's quality which, it will be remembered, is a Crossbred type of wool has withstood the processing with relatively small loss of length; the standard processing having only lost 2·3 per cent., and the high draft 4·1 per cent., with an average loss in the four processings of 3 per cent. But the more delicate 64's quality, Merino type, has suffered in its initially short mean length being considerably reduced, the corresponding losses being standard processing 14·2 per cent., high draft processing 20·6 per cent., with an average loss of 16·9 per cent.

Fig. 4 has been prepared to show the rate at which the various slubbings' decrease in mean length for the different settings. The following comments are based chiefly on the results given in this graph.

64's Quality. The standard, after a fall of mean length of 1·9 per cent., continues to decrease steadily, but at a slightly increasing rate until the 2nd finisher, then the rate of loss rapidly increases. The fibre breakage with the high ratch is very similar to that of the standard.

Approximately 56 per cent. greater fibre breakage is recorded by the high draft. This, however, does not occur until the last two processes, and, in all the stages of drawing to the 1st finisher the breakage is actually less than the standard. This would suggest that some fibre extension, or additional loss of crimp, has taken place, but the tests made on the crimp and elongation failed to reveal any such differences from the other processings. A further peculiarity noted for both high draft and high twist was that the decrease from reducer to rover was smaller than at the preceding stage of processing. No explanation can be offered for this.

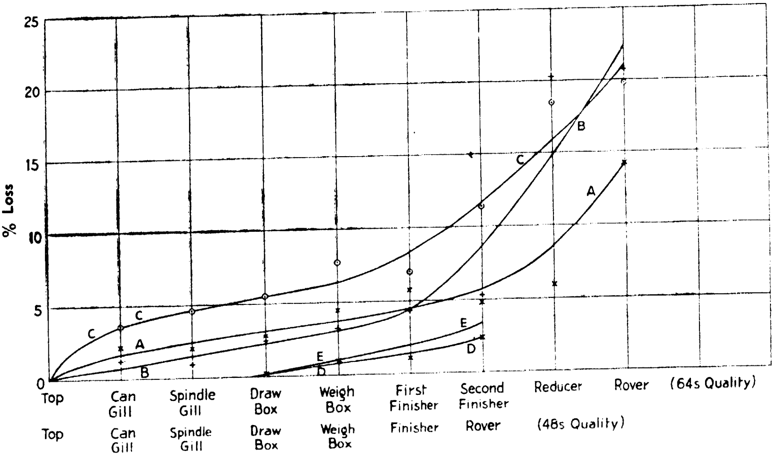

Fig. 4. Percentage decrease of mean fibre length due to fibre breakage.

64's Quality.
AA Standard Processing and High Ratch
BB High Draft *CC* High Twist

48's Quality.
DD Standard Processing and Ratch
EE High Draft and High Twist

The high twist has throughout caused considerably greater fibre breakage; this is 100 per cent. greater at the early machines but falls to approximately 50 per cent. at the final roving.

48's Quality. The only points of comment with respect to these results are that the high draft and high twist have each shown about 25 per cent. more fibre-breakage than the standard and high ratch, and the amount of fibre breakage at the gill boxes is negligible.

Fibre Breakage.

The above results have been obtained by noting the changes in the weight of the various groups of centimetre lengths. Hence, they show the effect of fibre breakage on the mean lengths but give no direct indication of the amount of fibre breakage itself. Certain conclusions have, however, been reached regarding the latter, as follows:—

The mean length may be expressed as $\frac{1}{N}\Sigma l$, where N is the number of fibres and Σl the sum of the fibre lengths. Assuming, as suggested on page 251, that the fibre is not extended by the breaking stress, the mean length will be reduced by the breakage of one fibre to $\frac{1}{N+1}\Sigma l$, as the number of fibres has in effect been increased by one, without altering the total length.

Therefore, the proportional decrease of mean length $= \frac{1}{N+1}$, where the proportion of fibres broken $= \frac{1}{N}$. Hence, a breakage of $\frac{1}{N}$ of the fibres, results in a mean length reduction of $\frac{1}{N+1}$ of the initial length.

Similarly a breakage of a proportion $\frac{n}{N}$ of the fibres will reduce the mean length by $\frac{n}{N+n}$.

Also, if the proportional reduction of mean length is represented by $\frac{m}{M}$, then the proportion of fibres broken will be $\frac{m}{M-m}$.

Neither the length of the fibre broken, nor the position of the fracture along its length, will affect these conclusions. They may be applied to the figures in Tables XV and XVI. For example, from Table XV the decrease of the grand mean length from top to final roving is 16·9 per cent., i.e., a reduction of $\frac{16 \cdot 9}{100}$, therefore, the fibre breakage will have been 20·3 per cent. The corresponding decrease in Table XVI is 3 per cent., giving a fibre breakage of 3·1 per cent.

The next point which arises is the effect on the whole distribution of the various lengths apart from that of the mean length. If the assumption is made that breakage takes place evenly throughout the different lengths, then the above adjustments may be made to each of the individual recorded weights. Thus, if the decrease of fibre length of the roving in Table I is too great by a similar amount to that of the roving in Table VI the true decrease will be as given by the broken line *AB*, in Fig. 1.

Finally, as stated on page 244, a larger proportion of longer fibres than short ones may be broken. To the extent to which this occurs, the breakage indicated by *AB* in Fig. 1 will still be too great. The actual amount of this is a matter of conjecture, but will almost certainly be small.

SUMMARY.

As a result of their passage through the operation of worsted open drawing, two qualities of wool have been noted to decrease in mean length. The decrease of the medium quality was small (3 per cent.) and was confined to the later processes, whilst the finer quality underwent a much greater decrease (17 per cent.), there being a substantial change with each operation.

Experiments made by increasing the draft and twist insertion each caused greater fibre breakage; approximately 50 per cent. more with the fine quality and 25 per cent. more with the medium quality. Increase of ratch did not appreciably affect the rates of fibre breakage. It was found that these changes of machine settings could only be made within narrow limits without impairing general processing efficiency. The changes were confined to these limits.

Changes in the recorded fibre lengths of the several slubbings and the rovings were noted to be due to:—

(*a*) fibre breakage;

(*b*) elongation of the fibres through loss of crimp;

(*c*) the differential action of the fibre length tester according to the form in which the fibres entered the tester. Each of these has been investigated.

No increases of the actual fibre length, nor any changes in properties of extension, were to be noted.

The results of the tests have been expressed as the mean fibre length of each slubbing or roving, and a method of calculating the actual amount of fibre breakage has been given.

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[3] Speakman. *J. Text. Inst.*, 1926, **17**, T467, and 1927, **18**, T437.
[4] Speakman. *J. Text. Inst.*, 1926, **17**, T466.
[5] Speakman. *J. Text. Inst.*, 1927, **18**, T434, Fig. 2.

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APPENDIX

For several reasons it was decided at the outset of the above work to carry out the tests by means of the Schlumberger machine in preference to any of the recognised alternative methods of measuring fibre length distribution. Nevertheless, bearing in mind the highly variable characteristics of any wool sample, particularly where blending has occurred, additional tests have been made to confirm, or otherwise, the data of Tables XV and XVI. These subsidiary tests were made by means of Wilkinson tufts[1] extracted from the top, 2nd finisher, reducer and rover. Three tufts were taken for each stage of the 64's quality, giving thirteen results, and five tufts each, with five results, for the 48's quality.

Difficulties were again encountered in extracting representative samples from the fine twisted roving, even after the preparations described on page 240. The most effective and expeditious method of obtaining the tufts was as follows:—

One person breaks the sliver or roving into strips, each at least twice the length of the longest fibre. Each end of a strip is taken between the thumb and finger, and all twist carefully removed, at the same time drafting slightly. Then, without releasing the ends, place between the thumbs and fingers of a second person. Repeat with all the strips, placing each one alongside the first one to form a group. The latter person, still gripping the slivers, places them conveniently on a table, and the former withdraws the tuft.

The results of these tests are given in the following table, the figures giving the mean fibre length in each case.

	64's Quality				48's Quality	
	Top	2nd finisher	Reducer	Rover	Top	Rover
Standard...	100	94·1	92·4	88·2	100	97·0
High draft		90·4	84·7	82·1		96·9
High twist		94·3	88·3	78·8		96·6
High ratch		94·8	93·6	84·3		97·6

These results agree in general with those of the initial tests, and confirm the conclusions already reached. No special comment is necessary in the case of the medium quality, the figures being very close to the corresponding ones of Table XVI.

The 64's quality, however, does raise two points :—

(*a*) The results, taken as a whole, do not show quite so great a change as those of Table XV. The average decrease of 2nd finisher, reducer and rover is 8·7 per cent. less than the average decrease of those in Table XV. By these figures, the decrease of the grand mean of Table XV, 16·9 per cent., would be reduced to 15·4 per cent. But against this it must be noted that this smaller decrease in the tuft tests is largely due to two figures, i.e., the high-draft and the high twist of the reducer. Also, of these twelve results, seven are smaller and five greater than the ones in Table XV.

(*b*) Whereas the high draft rover in Table XV shows a slightly greater decrease than the rover of the high twist, the reverse is found in the present tests. The two previous figures of the high twist above do not, however, substantiate this. Hence the isolated figure of 78·8 per cent. in the high twist rover cannot be employed to modify the conclusions previously reached.

REFERENCE

[1] Wilkinson. *J. Text. Sci.*, 1928, **2**, 104.

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